



Dayananda Sagar University
Devarakaggalahalli , Harohalli , Kanakapura Road ,Ramanagar
District- 562112

SCHEME AND SYLLABUS

B.Tech. PROGRAMME– 2023 BATCH

Definitions / Descriptions



Dayananda Sagar University

Devarakaggalahalli , Harohalli , Kanakapura Road ,Ramanagar

District- 562112

Definition of Credit:	
1 Hour Lecture (L) Per Week	01 Credit
1 Hour Tutorial (T) Per Week	0.5 Credit
1 Hour Practical (P) Per Week	0.5 Credit
1 Hour Project (J) Per Week	0.5 Credit

Course code and Definition:	
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management Courses
IPCC	Integrated Professional Core Course
PCC	Professional Core Courses
PEC	Professional Elective Courses
OEC	Open Elective Courses
SEC	Skill Enhancement Courses
UHV	Universal Human Value Course
PROJ	Project Work
INT	Internship



Dayananda Sagar University

**Devarakaggalahalli , Harohalli , Kanakapura Road ,Ramanagar
District- 562112**

**Implementation of National Education Policy
(NEP) 2020 for the B.Tech
students of Batch 2023-24**

The implementation of Curriculum follows NEP 2020 and addresses the following features and categories of courses:

1. Student Centric flexible curriculum.
2. Inter-disciplinary Courses,
3. Multi-disciplinary Courses,
4. Ability Enhancement Courses,
5. Skill Enhancement Courses,
6. Value Added Courses,
7. Product Design and Development,
8. Internship (Rural Internship, Industry Internship, Research/Development Internship), and
9. Multiple Exit and Multiple Entry
 - Certificate in Engineering after completion of first year.
 - Diploma in Engineering after completion of second year.
 - Advanced Diploma in Engineering after completion of third year.
 - Degree in Engineering after completion of fourth year



Dayananda Sagar University
Devarakaggalahalli , Harohalli , Kanakapura Road ,Ramanagar
District- 562112

SCHEME 2023 – 2027 Batch

I SEMESTER (Chemistry Cycle)

S.N	Course Type	Course Code	Course Name	Teaching Department	Specific to Department	Teaching Hours / Week				Examination				Credits
						Lecture	Tutorial	Practice	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
						L	T	P	J					
1	BSC	24EN1101	LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS	MAT	All Depts.	3	0	0	0	03	60	40	100	3
2	ESC	24EN1102	OBJECT ORIENTED PROGRAMMING	CSE	All Depts.	2	1	2	0	05	60	40	100	4
3	ESC	24EN1103	COGNITIVE AND TECHNICAL SKILLS – I	CHEM	All Depts.	2	0	2	0	04	60	40	100	3
4	ESC	24EN1104	ENGINEERING CHEMISTRY	ME	All Depts.	2	0	2	0	04	60	40	100	3
5	ESC	24EN1105	INTRODUCTION TO MECHANICAL ENGINEERING	ECE	All Depts.	2	0	0	0	2	60	40	100	2
6	ESC	24EN1106	INTRODUCTION TO ELECTRICAL ENGINEERING	ME	All Depts.	2	0	0	0	02	60	40	100	2
7	HSMC	24EN1107	ENGINEERING MECHANICS	HUM	All Depts.	2	0	0	0	2	100	--	100	2
8	AEC	24EN1108	TECHNICAL ENGLISH	Biology	All Depts.	1	0	0	0	01	100	--	100	1
9	HSMC	24EN1109	ENVIRONMENTAL SCIENCE	HUM	All Depts.	1	0	0	0	01	100	--	100	0
			Total			17	1	6	0	24				20

I SEMESTER (Physics Cycle)

S.N	Course Type	Course Code	Course Name	Teaching Department	Specific to Department	Teaching Hours / Week				Examination				
						Lecture	Tutorial	Practice	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	Credits
						L	T	P	J					
1	BSC	24EN1101	LINEAR ALGEBRA AND DIFFERENTIAL EQUATIONS	MAT	All Depts.	3	0	0	0	03	60	40	100	3
2	ESC	24EN1102	OBJECT ORIENTED PROGRAMMING	CSE	All Depts.	2	1	2	0	05	60	40	100	4
	BSC	24EN1103	COGNITIVE AND TECHNICAL SKILLS – I	PHY	All Depts.	3	0	2	0	05	60	40	100	4
3	ESC	24EN1111	ENGINEERING PHYSICS	ECE	All Depts.	3	0	0	0	03	60	40	100	3
5	ESC	24EN1112	INTRODUCTION TO ELECTRONICS ENGINEERING	ME	All Depts.	2	0	2	0	04	60	40	100	3
6	AEC	24EN1113	ENGINEERING GRAPHICS AND DESIGN THINKING	Biology	All Depts.	2	0	0	0	02	100	--	100	2
7	HSMC	24EN1114	BIOLOGY FOR ENGINEERS	HUM	All Depts.	1	0	0	0	01	100	--	100	1
Total						16	1	6	0					20

II SEMESTER (Chemistry Cycle)

II SEMESTER (Chemistry Cycle)														
S.N	Course Type	Course Code	Course Name	Teaching Department	Specific to Department	Teaching Hours / Week				Examination				Credits
						Lecture	Tutorial	Practice	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
						L	T	P	J					
1	BSC	24EN1201	SINGLE AND MULTIVARIATE CALCULUS	MAT	All Depts.	3	0	0	0	03	60	40	100	3
2	ESC	24EN1202	C PROGRAMMING FOR PROBLEM SOLVING	CSE	All Depts.	2	1	2	0	05	60	40	100	4
3	ESC	24EN1203	COGNITIVE AND TECHNICAL SKILLS – II	CHEM	All Depts.	2	0	2	0	04	60	40	100	3
4	ESC	24EN1104	ENGINEERING CHEMISTRY	ME	All Depts.	2	0	2	0	04	60	40	100	3
5	ESC	24EN1105	INTRODUCTION TO MECHANICAL ENGINEERING	ECE	All Depts.	2	0	0	0	2	60	40	100	2
6	ESC	24EN1106	INTRODUCTION TO ELECTRICAL ENGINEERING	ME	All Depts.	2	0	0	0	02	60	40	100	2
7	HS MC	24EN1107	ENGINEERING MECHANICS	HUM	All Depts.	2	0	0	0	2	100	--	100	2
8	AE C	24EN1108	TECHNICAL ENGLISH	Biology	All Depts.	1	0	0	0	01	100	--	100	1
9	HS MC	24EN1109	ENVIRONMENTAL SCIENCE	HUM	All Depts.	1	0	0	0	01	100	--	100	0

		Total	17	1	6	0	24		20



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II SEMESTER (Physics Cycle)													
S. N	Course Type	Course Code	Course Name	Teaching Department	Specific to Department	Teaching Hours / Week				Examination			
						Lecture	Tutorial	Practic	Project	Duration	CIE Marks	SEE Marks	Total Marks
						L	T	P	J				
1	BSC	24EN1201	SINGLE AND MULTIVARIATE CALCULUS	MAT	All Depts.	3	0	0	0	03	60	40	100
2	ESC	24EN1202	C PROGRAMMING FOR PROBLEM SOLVING	CSE	All Depts.	2	1	2	0	05	60	40	100
	BSC	24EN1203	COGNITIVE AND TECHNICAL SKILLS – II	PHY	All Depts.	3	0	2	0	05	60	40	100
3	ESC	24EN1111	ENGINEERING PHYSICS	ECE	All Depts.	3	0	0	0	03	60	40	100
5	ESC	24EN1112	INTRODUCTION TO ELECTRONICS ENGINEERING	ME	All Depts.	2	0	2	0	04	60	40	100
6	AEC	24EN1113	ENGINEERING GRAPHICS AND DESIGN THINKING	Biology	All Depts.	2	0	0	0	02	100	--	100
7	HSM C	24EN1114	BIOLOGY FOR ENGINEERS	HUM	All Depts.	1	0	0	0	01	100	--	100
Total						16	1	6	0				20

General Instructions:

- **Open Elective Courses:** At least two courses must be provided from each department and the courses shall be general course on emerging areas with broad coverage of syllabus so that student shall choose without any difficulty.
- **Honors Degree:** An Honors degree typically refers to a higher level of academic achievement in the major area. That is, certificate in his/her OWN major for Research orientation. The Credit requirement: **172 to 178 credits** (Major worth 160 credits + Honors 12 to 18 credits)
- **Minor Degree:** Minor is a secondary concentration of courses that often complements the honors. Minor in any OTHER branch for Improving Employability.
 - Minor is an option rather than a requirement for B. Tech students. They may opt for one of the Engineering or Non- engineering discipline as Minor, earning additional credits ranging from 12 to 18. However, students are permitted to choose only one Minor either from engineering or Non-engineering discipline.
 - This opportunity is ideal for students who took a Major out of necessity but would still like to pursue their passion in another discipline or to enrich/equip them for a specific profession where greater job opportunities exist. Another advantage of opting for a Major with a Minor is to earn standing credits for pursuing a Master's degree abroad or within India too.
 - Only students who satisfy a set of minimum eligibility criteria set forth by the university and meet certain pre-requisites, will be permitted to opt for a Minor.
 - Credit requirement: **172 to 178 credits** (Major worth 160 credits + Minor 12 to 18 credits)
 - Degree nomenclature: The degree will contain the Major / Major with Specialization. The Minor pursued by the student will be provided in the transcript along with details on courses completed and associated credits earned.
 - For e.g., For a student who pursued Computer Science and Engineering with a Minor in Industrial Psychology, the degree will read "B. Tech in Computer Science and Engineering", Transcripts of B. Tech will reflect the Minor courses and the Minor certificate in Industrial Psychology will be issued separately.

LINEAR ALGEBRA & DIFFERENTIAL EQUATIONS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Course Code	: 23EN1101	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-J	: 3-0-0-0		
Course Learning Objectives: This Course will enable students to: 1. Apply the method of Gauss elimination to solve systems of linear equations and determine the row echelon form of a matrix 2. Analyze vector spaces, subspaces, and their properties to identify linear independence, span, and bases in the context of finite-dimensional vector spaces. 3. Evaluate and compute the dimensions of vector spaces by understanding the concepts of rank and nullity 4. Analyze the properties and characteristics of linear transformations and their corresponding matrices to gain a deeper understanding of their behaviour and applications. 5. Utilize the concepts of eigenvalues and eigenvectors, employing diagonalization techniques to determine the diagonal form of a matrix and its implications in various contexts.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different types of teaching methods may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 6. Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I			08 Hours
INTRODUCTION: System of Linear equations. (<i>Text Book-1: Chapter 1: 1.1</i>) Row reduction and echelon form. (<i>Text Book-1: Chapter 1: 1.2</i>) Rank of a matrix by row echelon form. (<i>Text Book-1: Chapter 4: 4.6</i>) Gauss elimination, Inverse of a matrix by Gauss Jordan (<i>Text Book-5: Chapter 3: 3.7 and 3.11</i>) LU decomposition (<i>Text Book-1: Chapter 2: 2.5</i>),			

UNIT – II													08 Hours	
Vector spaces – Subspaces (<i>Text Book-1: Chapter 4: 4.1</i>) Linear independence – Span - Bases and Dimensions -Finite dimensional vector spaces (<i>Text Book-1: Chapter 4: 4.3</i>) Dimensions, finite dimensional vector spaces (<i>Text Book-1: Chapter 4: 4.5</i>)														
UNIT – III													09 Hours	
Linear transformation - Matrices of linear transformations (<i>Text Book-1: Chapter 1: 1.7 and 1.8</i>) Vector space of linear transformations – Inner Product, Orthogonal Vectors - Projections (<i>TextBook-1: Chapter 6: 6.1, 6.2 and 6.3</i>) Gram- Schmidt Orthogonalization process (<i>Text Book-1: Chapter 6: 6.4</i>)														
UNIT – IV													07 Hours	
Introduction to Eigenvalues and Eigenvectors (<i>Text Book-1: Chapter 5: 5.1</i>) Diagonalization of a Matrix (<i>Text Book-1: Chapter 5: 5.3</i>)														
UNIT – V													07 Hours	
Linear second order ordinary differential equation with constant coefficients (<i>Text Book-5:Chapter 2</i>) Solutions of homogenous and non-homogenous equations (<i>Text Book-5: Chapter 2: 2.2 to 2.7</i>)Method of variation of parameters (<i>Text Book-5: Chapter 2: 2.10</i>) Solutions of Cauchy-Euler and Cauchy-Legendre differential equations (<i>Text Book-5: Chapter2: 2.5</i>)														
Course Outcomes: At the end of the course the student will be able to: 1. Solve systems of linear equations using Gauss elimination and determine the inverse of a matrix by applying the Gauss-Jordan method. 2. Solve problems involving row reduction and echelon form in linear algebra to demonstrate an understanding of the concepts and their applications in solving systems of linear equations and transforming matrices. 3. Analyze matrices and determine their rank by using row echelon form, examining the relationships between rows and columns, and identifying the motives or causes behind the rank. 4. Apply LU decomposition techniques to factorize a matrix into lower and upper triangular matrices, illustrating their understanding of the process and its applications. 5. Apply the concepts of vector spaces, subspaces, linear independence, span, bases, and dimensions to solve problems related to finite-dimensional vector spaces, applying acquired knowledge and techniques.														
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1						1					
CO2	3	2	1		1				1					
CO3	3	2	1		1				1					
CO4	3	2	1						1					
CO5	3	2	1		1				1					

3: Substantial (High)

**2: Moderate (Medium)
(Low)**

1: Poor

TEXT BOOKS:

1. D C Lay, S R Lay and JJ McDonald, Linear Algebra and its Applications, Pearson India, Fifth edition.
2. Linear Algebra and its Applications by Gilbert Strang, 4th Edition, Thomson Brooks/Cole, Second Indian Reprint 2007.
3. Introductory Linear Algebra- An applied first course, Bernard Kolman and David, R. Hill, 9th Edition, Pearson Education, 2011.
4. Thomas' Calculus, George B. Thomas, D. Weir and J. Hass, 2014, 13th edition, Pearson.
5. Advanced engineering mathematics, Erwin Kreyszig, Wiley, London, 1972.

REFERENCE BOOKS:

1. Introduction to Linear Algebra, Gilbert Strang, 5th Edition, Cengage Learning (2015).
2. Higher Engineering Mathematics by B S Grewal, 42nd Edition, Khanna Publishers.
3. Elementary Linear Algebra, Stephen Andrilli and David Hecker, 5th Edition, Academic Press (2016).
4. Contemporary linear algebra, Howard Anton, Robert C Busby, Wiley 2003.
5. Practical Linear Algebra, Farin and Hansford, CRC Press (2013).

E-Resources:

1. <https://nptel.ac.in/courses/111101115>
2. <https://nptel.ac.in/courses/111108066>
3. Linear Algebra Basics | Coursera
4. <https://nptel.ac.in/courses/111108081>
5. <https://nptel.ac.in/courses/111106100>
6. Differential Equations for Engineers Course (HKUST) | Coursera

Activity Based Learning (Suggested Activities in Class)

1. Introduce the concept of matrix transformations, such as translation, rotation, scaling, and reflection. Provide visual examples and interactive tools that allow students to manipulate shapes and observe the effects of different transformation matrices.
2. Using real-life scenarios or word problems to make the activity of solving linear equations using matrix method.
3. Some real-world scenarios that can be modelled using ODEs, such as population growth, radioactive decay, or chemical reactions that can be discussed and solve using appropriate methods.

ENGINEERING CHEMISTRY [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER - I/II	
Course Code : 23EN1103	Credits : 03
Hours / Week : 04 Hours	Total Hours : 26 + 26 Hours
L-T-P-J : 2-0-2-0	
<u>Course Learning Objectives:</u> This Course will enable students to: • Understand the principles of chemical fuel towards energy production. • Apply the concept of energy conversion from solar to electric energy in photovoltaic cells. • Understand the basic principles of electrochemistry to measure the potential of redox reactions. Illustrate the construction, working, and applications of batteries, and fuel cells as energy storage devices. • Understand the electrochemical theory of corrosion of metals and its prevention by metal finishing techniques. • Understand the synthesis, structure-property relationship, and the applications of commercial polymers. • Understand the different techniques for the purification of sewage water. Analyse the impurities present in waste water systems.	
Teaching-Learning Process (General Instructions) These are some of the innovative pedagogical approaches to accelerate the attainment of the various course outcomes. 1. Lecture method: Chalk and talk method, and demonstrations may be adopted to achieve the course outcomes. 2. Interactive Teaching: Active learning that includes brainstorming, group work, formulating questions, note taking, and annotating. 3. Show Videos to explain and illustrate the various concepts. 4. Encourage Collaborative learning in the class. 5. Problem Based Learning, may foster students' analytical skills, ability to evaluate, and process the information. 6. Inculcate the culture of research and encourage students to come up with their own creativity.	
UNIT - I Chemical Energy Source	06 Hours
Fuels: Introduction to energy; Fuels - definition, classification, importance of hydrocarbons as fuels; Calorific value-definition, Gross and Net calorific values (SI units). Determination of calorific value of a solid / liquid fuel using Bomb calorimeter. Numerical problems on GCV&NCV. Petroleum cracking-fluidized catalytic cracking. Reformation of petrol. octane number, cetane number, anti-knocking agents, power alcohol, and Biodiesel. (Text Book-1: Module-3) Solar Energy: Thermal energy: Photovoltaic cells-Introduction, definition, importance, working of PV cell. Solar grade silicon physical and chemical properties relevant to photovoltaics, doping of silicon by diffusion technique. (Text Book-1: Module-3)	

UNIT – II Energy Science and Technology	06 Hours
Electrochemistry and Battery Technology: Single electrode potential - Definition, and sign conventions. Standard electrode potential- Definition. EMF of a cell-Definition, notation and conventions. Reference electrodes– Calomel electrode, Ag/AgCl electrode. Measurement of standard electrode potential. Battery technology: Basic concepts including characteristics of anode, cathode, electrolyte and separator. Battery characteristics. Classification of batteries– primary, secondary and reserve batteries. State of the art Batteries-Construction working and applications of Zn-air, Lead acid battery, Nickel-Metal hydride and Lithium ion batteries. <i>(Text Book-2: Module-1)</i> Fuel Cells: Introduction to fuel cells, types of fuel cells. Construction, working and application of Methanol-Oxygen fuel cell. <i>(Text Book-2: Module-1)</i>	
UNIT – III Corrosion Science and Surface Modification Techniques	06 Hours
Corrosion Science: Definition, Chemical corrosion and Electro-chemical theory of corrosion, Types of corrosion, Differential metal corrosion, Differential aeration corrosion (pitting and water line corrosion), Stress corrosion. Factors affecting the rate of corrosion, Corrosion control: Metal coatings-Galvanization, Tinning and its disadvantages. Cathodic protection of Corrosion: Sacrificial anode method and current impression method. <i>(Text Book-2: Module-2)</i> Surface Modification Techniques: Definition, Technological importance of metal finishing. Significance of polarization, decomposition potential and over-voltage in electroplating processes. Electroless Plating. Distinction between electroplating and Electroless plating, advantages of electroless plating. Electroless plating of copper. <i>(Text Book-2: Module-2)</i>	
UNIT – IV Polymers	02 Hours
Polymers: Introduction to polymers, Glass transition temperature, structure and property relationship. Synthesis, properties and applications of Teflon. PMMA. Synthesis, properties and application of silicone rubber. <i>(Text Book-1: Module-4)</i>	
UNIT – V Water Technology & Instrumental Methods of Analysis:	06 Hours
Water Technology: Impurities in water. Hardness of Water: Types of Hardness and determination of total hardness of water by using disodium salt of ethylenediaminetetraacetic acid method. Alkalinity. Potable water treatment by Electro dialysis and Reverse Osmosis. Water analysis- Biochemical oxygen demand and Chemical oxygen demand. Determination of COD. Numerical problems on COD. Sewage treatment. <i>(Text Book-2: Module-5)</i> Instrumental Methods of Analysis: Instrumental methods of analysis, Principles of Potentiometry, Conductometry (Strong acid against strong base, weak acid against strong base, mixture of strong acid and a weak acid against strong base).	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Determination of calorific value of fuels and apply the concepts of energy conversion for photovoltaic cells.	L3
2	Apply the basic principles of electrochemistry for the construction of energy storage devices.	L3
3	Implement the electrochemical theory to analyze the concept of corrosion of metals and its prevention by surface modifications.	L3
4	Apply the concept of polymerization for the synthesis of polymers and study their structure-property relationship for commercial applications.	L3
5	Demonstrate the techniques in the purification of sewage water. Determine the hardness and oxygen demand of the provided waste water samples.	L2

Table: Mapping Levels of COs to POs												
COs	Program Outcomes (POs)											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3	3	3	0	0	0	0	0	0	0	0	0
CO2	3	2	2	0	0	0	0	0	0	0	0	0
CO3	3	1	1	0	0	0	0	0	0	0	0	0
CO4	3	1	3	0	0	0	0	0	0	0	0	0
CO5	3	1	3	0	0	0	0	0	0	0	0	0

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books

1. Engineering Chemistry, Edited by Dr. Mahesh B and Dr. Roopashree B, Sunstar Publisher, Bengaluru, ISBN 978- 93-85155-70-3, 2022.
2. Engineering Chemistry - by Chandra Shekara B M and Basavaraju B C, Banbayalu (publications), Bengaluru, 2014, 294 pages.

Reference Books

1. Prasanta Rath, "Engineering Chemistry", Cengage Learning India PVT, LTD, Delhi, 2015.
2. Shikha Agarwal, "Engineering Chemistry-Fundamentals and Applications", Cambridge University Press, Delhi, 2015.
3. Wiley's Engineering Chemistry (Wiley India), 2nd Edition, 2013, 1026 pages.

E-Resources

1. <https://nptel.ac.in/>

2. <https://swayam.gov.in/>

3. [https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental Modules \(Analytical Chemistry\)/Electrochemistry/Basics of Electrochemistry](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Supplemental_Modules_(Analytical_Chemistry)/Electrochemistry/Basics_of_Electrochemistry)

Activity Based Learning (Suggested Activities in Class)

1. Analyze research problems by reading research articles, group discussion, and presentations.
2. Demonstration of solution to a problem through experiential learning.
3. Demonstrations using real objects, taking students on an educational tour.

ENGINEERING CHEMISTRY- LABORATORY

Total: 26 Hrs

Volumetric Analysis and Preparations

1. Evaluation of quality of water in terms of total hardness by complexometric titration.
2. Determination of Chemical Oxygen Demand (COD) of the given industrial waste water sample.
3. Determination of alkalinity of the given water sample

Instrumental methods of Analysis

1. Potentiometric titration–Estimation of FAS using standard $K_2Cr_2O_7$ solution.
2. Conductometric estimation of a mixture of a weak and strong acid using standard sodium hydroxide solution
3. Determination of viscosity coefficient of a given liquid
4. Colorimetric estimation of copper in a given solution
5. Determination of pKa of given weak acid.

Reference Books

1. Dayananda Sagar University laboratory manual.
2. J. Bassett, R.C. Denny, G.H. Jeffery, Vogels, Text book of quantitative inorganic analysis, 4th Edition.

INTRODUCTION TO MECHANICAL ENGINEERING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER - I/II	
Course Code :	Credits : 03
Hours / Week : 04 Hours	Total Hours : 26+26 Hours
L-T-P-J : 2-0-2-0	
Course Learning Objectives: This course enables students to: 1. Acquire a basic understanding of renewable energy resources and basic concepts of hydraulicturbines. 2. Acquire knowledge of various engineering materials and metal joining techniques. 3. Acquire essential knowledge of modern manufacturing tools and techniques. 4. Acquire knowledge on basics of refrigeration and air-conditioning. 5. Explain about the cooling of electronic devices. 6. Acquire knowledge of basic concepts of mechatronics and robotics. 7. Explain about the electric and hybrid vehicles.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainmentof the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 6. Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
MODULE 1 Energy Sources and Power Generation	10 Hrs
Review of energy sources: Construction and working of Hydel power plant, Thermal power plant, Nuclear power plant, Solar power plant, Tidal power plant, Wind power plant. Principle and Operation of Hydraulic turbines, Pelton Wheel, Francis Turbine and Kaplan Turbine. Working of Centrifugal Pump&reciprocating pump. Thermodynamics: System, boundary, surroundings, types of systems, Zeroth law, First and second laws of thermodynamics, Efficiency, COP, Carnot theorem	
MODULE 2 Engineering Materials and Metal Joining Processes	10 Hrs

Metals-Ferrous: Tool steels and stainless steels. Non-ferrous /metals: aluminum alloys.
Ceramics- Glass, optical fiber glass, cermets. **Composites-** Fiber reinforced composites, Metal matrixComposites.
Smart materials- Piezoelectric materials, shape memory alloys, semiconductors, and super-insulators.
Metal Joining Processes: Fitting, Sheet metal, Soldering, brazing and Welding: Definitions. Classificationand methods of soldering, brazing, and welding. Brief description of arc welding, Oxy- acetylene welding, Introduction to TIG welding and MIG welding.

MODULE 3 Modern Manufacturing Tools and Techniques		12 Hrs
CNC: Introduction, components of CNC, advantages and applications of CNC, CNC Machining centres andTurning Centers Concepts of Smart Manufacturing and Industrial IoT.		
Additive Manufacturing: Introduction to reverse Engineering, Traditional manufacturing vs Additive Manufacturing, Computer aided design (CAD) and Computer aided manufacturing (CAM) and Additive Manufacturing (AM), Different AM processes, Rapid Prototyping, Rapid Tooling,		
3D printing: Introduction, Classification of 3D printing process, Applications to various fields.		
MODULE 4 Thermal Systems and Management		10 Hrs
Heat in Electronic Devices: Modes of Heat Transfer, heat generation in electronics, temperaturemeasurement, heat sink, Cooling of electronic devises: Active, Passive, and Hybrid Cooling.		
Refrigeration: Principle of refrigeration, Refrigeration effect, Ton of Refrigeration, COP, Refrigerants andtheir desirable properties. Principles and Operation of Vapor Compression and Vapor absorption refrigeration. Applications of Refrigerator.		
Air-Conditioning: Classification and Applications of Air Conditioners. Concept and operation of Centralized air conditioning system.		
MODULE 5 Advanced Technologies		10 Hrs
Mechatronics: Introduction, Concept of open-loop and closed-loop systems, Examples of Mechatronicssystem and their working principle.		
Robotics: Introduction, Robot anatomy, Joints & links, common Robot configurations. Applications of Robotics in Material Handling, Processing, Assembly, and Inspection.		
Electric and Hybrid Vehicles: Introduction, Components of Electric and Hybrid Vehicles, Drives andTransmission. Advantages and disadvantages of EVs and Hybrid vehicles.		

List of Laboratory/Practical Experiments activities to be conduct

1. Demonstration on Principle and Operation of any one Turbo machine
2. Demonstration on pumps
3. Visit any one Conventional or Renewable Energy Power Plant and prepare a comprehensive report.
4. One exercises each involving Fitting and Sheet metal.One exercises each involvingwelding and Soldering.
5. Study oxy-acetylene gas flame structure and its application to gas welding
6. Demonstration on Principle and Operation of CNC machine.
7. Demonstration on Principle and Operation of 3D printing process.
8. Demonstration of anyone Heat transfer application device and prepare a comprehensive report.
9. Demonstration of anyone air conditioning system.
10. Demonstration of the machine consists of Gear Trains.
11. Demonstration of various elements of mechatronic system.
12. Demonstration of any one model of Robot

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Describe the operational mechanisms and efficiencies of various types of power plants such as hydel, thermal, nuclear, and renewable energy sources.	L2												
2	Identify different metal joining processes including welding, soldering, and brazing, with a focus on their applications and limitations.	L2												
3	Recognize the components and functions of CNC machines and the fundamental principles of additive manufacturing processes.	L2												
4	Categorize the modes of heat transfer, thermal management strategies, and cooling techniques used in electronic devices.	L2												
5	Identify the key components and basic operational principles of electric and hybrid vehicles, including their transmission systems and power sources.	L2												
6	Demonstrate practical skills and understanding through hands-on exercises in fitting, sheet metal work, welding, soldering, and detailed demonstrations of CNC machining and 3D printing processes.	L3												
Table: Mapping Levels of Cos to Pos / PSOs														
Cos	Program Outcomes (Pos)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	2					2				2	3
C02	2	3	1	3	3	2	1	1	3	2	1	1	3	2
C03	2	3	1	3	2	1	2	2	2	3	2	1	2	3
C04	2	3	1	3	1	1	1	1	3	3	3	2	3	3
C05	1	3	3	2	3	3	3	3	1	1	2	3	3	3
C06	1	3	3	2	3	3	3	3	1	1	2	3	3	3

TEXT BOOKS:

1. Basic and Applied Thermodynamics, P.K.Nag, Tata McGraw Hill 2nd Ed., 2002
2. Non-Conventional Energy Sources, G.D Rai, Khanna Publishers, 2003
3. Elements of Workshop Technology (Vol. 1 and 2), Hazra Choudhry and Nirzar Roy, Media Promoters and Publishers Pvt. Ltd., 2010
4. Thermal Management in Electronic Equipment, HCL Technologies, 2010
5. Robotics, Appu Kuttan KK K. International Pvt Ltd, volume 1

REFERENCES:

1. An Introduction to Mechanical Engineering, Jonathan Wickert and Kemper Lewis, Third Edition, 2012
2. Turbo Machines, M. S. Govindgowda and A. M. Nagaraj, M. M. Publications 7th Ed, 2012
3. Manufacturing Technology- Foundry, Forming and Welding, P.N.Rao Tata McGraw Hill 3rd Ed., 2003.
4. Thermal Management of Microelectronic Equipment, L. T. Yeh and R. C. Chu, ASME Press, New York, 2002
5. Fundamentals of Robotics: Analysis and Control, Robert J. Schilling, Pearson Education (US).

INTRODUCTION TO ELECTRICAL ENGINEERING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – I/II	
Course Code : 23EN1105	Credits : 02
Hours / Week : 02 Hours	Total Hours : 26 Hours
L-T-P-J : 2-0-0-0	
<u>Course Learning Objectives:</u> This course enables students to: • Demonstrate a foundational understanding of electrical quantities, including current, voltage, power, and energy. • Apply fundamental laws of electric circuits, such as Ohm's law and Kirchhoff's laws to evaluate electrical circuits. • Explain fundamental concepts of electro-magnetic circuits. • Demonstrate a foundational understanding of the working principles, construction, and characteristics of DC machines. • Illustrate the construction, operation, and types of transformers, considering their significance in electrical systems. • Explain the structure and components of electrical power system, highlighting their interconnections. • Explain emerging trends of green energy technologies and smart metering. • Explain the importance of earthing, protective devices, and proper wiring for ensuring electrical safety.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 9. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 10. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 11. Show Video/animation films to explain functioning of various concepts. 12. Encourage Collaborative (Group Learning) Learning in the class. 13. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 14. Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 15. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 16. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	10 Hours
Fundamentals laws of Electrical circuit and elements: Electrical charge, potential; current; power and energy; AC and DC current (mathematical treatment); Ohm's law; KCL and KVL in resistive circuits; series and parallel combination of resistors; voltage and current division rule;	

V-I relationships for inductor and capacitor under AC voltage; impedance and admittance (series RC and RL); Overview of active power, reactive power and power factor; Introduction to 3 phase systems; Simulation using LTspice software to demonstrate voltage division, current division in resistive circuits. Simulation using LTspice software to show voltage and current waveform for RC and RL circuit.

**(TextBook-1: Chapter 1: 1.1 to 1.4, 1.6 to 1.8. Chapter 2: 2.1 to 2.3. Chapter 4: 4.1 to 4.4
Chapter 6: 6.1 to 6.4)**

UNIT – II		10 Hours
Electromagnetic circuits: Magnetic circuits: Basics of magnetic circuits (flux, mmf, permeability, reluctance, B and H); Relation between field theory and circuit theory; Faraday's and lenz's laws, Lorentz force; Self and Mutual inductance. DC machines: Principle of operation of DC generator; generated EMF equation; classification; characteristics and applications. (Introductory treatment only); Principle of operation of DC Motor; back EMF; speed and torque; classification; characteristics and applications. Losses and efficiency in DC machines. Transformers: Construction, working principle, induced emf equation; step-up and step down; losses and efficiency.		
(TextBook-2: Chapter 7: 7.1 to 7.12; Textbook 1: 10.1, 10.2, 10.4, 10.5, 10.8, 10.9, 10.11 and 10.12; Chapter 8: 8.1, 8.2 and 8.9)		
UNIT – III		06Hours
Powers system fundamentals: Power system structure; generations sources; green energy; smart meters; power tariff calculations; Electrical safety and standards (IS: 732-2019, IEC: 60446); Colour code of wires for single phase supply, earthing, fuse and MCB.		
(Textbook 1: , Chapter 16: 16.1 to 16.5; Textbook 2: Chapter 24: 24.1 to 24.6)		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
CO1	Solve for voltage, current, power and energy in purely R, series RL and RC circuits under DC and AC voltages.	L3
CO2	Demonstrate understanding of principle of operation of DC machines and its applications.	L2
CO3	Demonstrate understanding of the working principle of transformers.	L2
CO4	Demonstrate understanding of the working principle of transformers, generation sources, the significance of renewable energy sources in electrical engineering, and safety practices.	L2
CO5	Demonstrate proficiency in using simulation software (e.g., LTspice) to simulate and solve electrical parametrs.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
C01	3	2		1	3						1		1		
C02	3	2									1		1		
C03	3	2									1		1		
C04	3					2	3	2			1		1	1	2
C05	3	3	2	1	3				1	1	2	2	1	1	

TEXT BOOKS:

1. D.P.Kothari and I.J. Nagrath, "Basic Electrical Engineering", 4th Edition, Tata McGraw Hill, 2019.
2. B.L. Theraja and A.K. Therja, "A textbook of electrical technology, Vol. I (Basic electrical Engineering)", S. Chand Publishing, 23rd Rev Ed, 2006.

REFERENCE BOOKS:

1. Clayton Paul, Syed A Nasar and Louis Unnewehr, "Introduction to Electrical Engineering", 2nd Edition, McGraw-Hill, 1992.
2. William H Hayt and Jack E Kimberly and Steven M Durbin, "Engineering Circuit Analysis" 8th Edition, McGraw-Hill, 2013.

E-Resources:

1. <https://nptel.ac.in/courses/108/108/108108076>

Activity Based Learning (Suggested Activities in Class):

1. Real world problem solving using group discussion and hands-on activities. E.g., Interfacing different types of sensors using Arduino.
2. Simulation of different electrical circuits. E.g., RL and RC circuits.

C PROGRAMMING FOR PROBLEM SOLVING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – I	
Course Code : 23EN1102	Credits : 04
Hours/Week : 05 Hours	Total Hours : 26(L) + 13(T) + 26 (P) Hours
L-T-P-J : 2-1-2-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Elucidate the basic architecture and functionalities of C programming language. 2. Apply programming constructs of C language to solve the complex problems 3. Explore data structures like arrays, structures, unions and pointers in implementing solutions to real world problems 4. Design and Develop Solutions to problems using structured programming constructs such as functions.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 6. Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that possible, it helps improve the students' understanding.	
UNIT – I	07 Hours
Basics and overview of C: Introduction to Problem Solving using Algorithms and Flowchart: Key features of Algorithms: Sequence, Decision, Repetition with examples. Background, structure of C program, keywords, Identifiers, Data Types, Variables, Constants, Input / Output statements, Operators (Arithmetic, relational, logical, bitwise etc.), Expressions, Precedence and Associativity, Expression Evaluation, Type conversions. Conditional Branching Statements-if and switch statements, iterative statements (loops)-while, for, do-while statements, Loop examples, Nested loops, break, continue, go to statement. (Text Book-1: Chapter 2 & Chapter 3)	
UNIT – II	05 Hours
Arrays: Introduction, declaration & initialization of array, reading and writing array elements,	

Operations on array: Traversal, searching (Linear and Binary search), sorting (Bubble sort and Selection Sort). Declaration and Initialization of two-dimensional arrays. Matrix Operations (addition, subtraction, multiplication, transpose) using two-dimensional array.

Strings: Definition, declaration, initialization, and representation. String handling functions and character handling functions.

(Text Book-1: Chapter 5:5.1 to 5.9 & Chapter 6)

UNIT - III

06 Hours

Pointers: Definition and declaration and initialization of pointers. Accessing values using pointers. Accessing array elements using pointers.

Functions: Definition and declaration. Built-in functions and User-defined functions. Categories of functions with example. Pointers as function arguments, array as function argument, Call-by-value and call-by-reference. Recursion.

(Text Book-1: Chapter 7: 7.1 to 7.17 & Chapter 4:4.1 to 4.8, 4.10)

UNIT - IV

04 Hours

Structures: Purpose and usage of structures. Declaration of structures. Assignment with structures. Structure variables and arrays. Nested structures. Student and employee database implementation using structures.

Unions: Declaration and initialization of a union. Difference between structures and unions. Example programs.

(Text Book-1: Chapter 8: 8.1, 8.2,8.6)

UNIT - V

04 Hours

Memory allocation in C programs: Dynamic memory allocation, memory allocation process, allocating a block of memory, releasing the used space, altering the size of allocated memory.

Files: Defining, open, read, write, seek and closing of both textual and random files.

(Text Book-1: Chapter 7: 7.18 to 7.20 & Chapter 9: 9.1 to 9.5, 9.8)

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply programming constructs of C language to solve the real-world problem.	L3
2	Choose appropriate data type for implementing solutions to solve problems like searching and sorting.	L3
3	Examine suitable user-defined data structures in implementing solutions, using modular programming constructs.	L4
4	Analyze efficient ways for managing data and storage.	L4
5	Justify a solution using a modern IDE and associated tools, conduct a code review and contribute in a small-team.	L5

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3													
CO2		2												
CO3			2										1	
CO4				2										
CO5					3				2				1	

3: Substantial (High)

2: Moderate (Medium)

1:

Poor (Low)

TEXT BOOKS:

1. Reema Thareja, "Programming in C". Oxford University Press, Second Edition, 2016.

REFERENCE BOOKS:

1. Brian W. Kernigham and Dennis M. Ritchie, (2012) "The C Programming Language", 2nd Edition, PHI.
2. Behrouz A. Forouzan, Richard F. Gilberg, "Computer Science - A Structured Approach Using C", Cengage Learning, 2007.
3. Vikas Gupta, "Computer Concepts and C Programming", Dreamtech Press 2013.

E-Resources:

1. <https://nptel.ac.in/courses/106/105/106105171/> MOOC courses can be adopted for more clarity in understanding the topics and verities of problem-solving methods.
2. <https://www.w3schools.com/c/index.php>
3. <https://www.guvi.in/courses/web-development/c-programming/>
4. <https://www.tutorialspoint.com/cprogramming/index.htm>
5. <https://pythontutor.com/>

Activity Based Learning (Suggested Activities in Class)

- Demonstration of solution to a problem through designing the Flowchart or any design notations using **draw.io** in the group of four and justify using snippets or algorithms.

C PROGRAMMING FOR PROBLEM SOLVING LABORATORY

Total Contact Hours: 26

List of Laboratory/Practical Experiments activities to be conducted

1. Programming Basics: Swapping Numbers, Simple Interest, and Factorial.
2. Quadratic Equation Solver
3. Number Operations: Palindrome Check and Power Calculation.
4. Fibonacci Series and Greatest Common Divisor (GCD) Calculation.
5. Calculator Emulation
6. String Manipulation
7. Sorting an Array of Integer Elements.
8. Searching an Array of Elements.
9. Pointer Demonstration using Functions.
10. Case Study on Strings and Functions.

ENGINEERING MECHANICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I/II

Course Code : 23EN1106	Credits : 02
Hours / Week : 02 Hours	Total Hours : 26 Hours
L-T-P-J : 2-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Illustrate Couples and equivalent force couple system 2. Understand the principles of resolution and composition of forces 3. Calculate moment of coplanar concurrent and coplanar non-concurrent forces 4. Draw free body diagrams of objects subjected to coplanar concurrent and non-concurrent force systems 5. Calculate center of gravity/centroid for various planar figures 6. Determine area moment of inertia for various planar geometrical objects and standard symmetrical sections 7. Explain Limiting friction and Laws of Friction 8. Solve numerical on wedge friction, ladder friction 9. Explain assumptions made in analysis of Trusses 10. Determine axial forces in members of Planar determinate Truss 11. Illustrate rectilinear, plane curvilinear and projectile motions	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 6. Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I Introduction to Engineering Mechanics	06 Hours
INTRODUCTION: Introduction to Engineering Mechanics, Force Systems Basic concepts, Particle Equilibrium in 2-D; System of Forces, Co-planar Concurrent Forces, Resultant- Moment of Forces and its Application; Couples and Resultant of force System, Equilibrium of System of Forces,	

UNIT – II Centroid, Centre and gravity and Moment of inertia	05 Hours
Introduction, Centroid of simple figures from first principle, centroid of standar sections Centre of Gravity and its implications; Area moment of inertia Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections	
UNIT – III Friction	05 Hours
Introduction, Free body diagrams, Equations of Equilibrium. Types of friction, Limiting friction, Cone of Friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, related problems.	
UNIT – IV Dynamics	05 Hours
Introduction, Rectilinear motion; Plane curvilinear motion (rectangular path, and polar coordinates); Projectile motion, Basic terms, general principles in dynamics; Types of motion, motion and simple problems, Kinetics- Newton's laws of motion and related problems.	
UNIT – V Analysis of Trusses	05 Hours
Introduction, Classification of trusses, Equilibrium in two and three dimension; Method of Joints; To determine if a member is in tension or compression; Simple Trusses; Zero force members.	
Course Outcomes: At the end of the course the student will be able to: 1. Compute Resultant and reactions by principles and resolution of forces in a plane. 2. Analyse the objects under the action of applied and frictional forces in a plane by equations of equilibrium. 3. Determine the Moment of Inertia of composite geometrical sections in a plane 4. Analyse determinate two-dimensional truss by the method of joints and method of section. 5. Analyze the motion of objects by equations of motion, equations of equilibrium, and Newton's laws of motion and calculate quantities in projectile motion by equations of motion.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Compute Resultant and reactions by principles and resolution of forces in a plane.	L2
2	Analyse the objects under the action of applied and frictional forces in a plane by equations of equilibrium.	L3
3	Determine the Moment of Inertia of composite geometrical sections in a plane	L2
4	Analyse determinate two-dimensional truss by the method of joints and method of section.	L3
5	Analyze the motion of objects by equations of motion, equations of equilibrium, and Newton's laws of motion and calculate quantities in projectile motion by equations of motion.	L3

Table: Mapping Levels of COs to POs / PSOs															
COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	0	0	1	1	0	0	0	0	1	3	2
CO2	2	2	2	2	0	0	1	0	0	0	0	0	2	2	0
CO3	3	3	2	2	0	0	1	0	1	0	0	0	3	2	0
CO4	3	3	2	2	0	0	1	0	0	0	0	0	3	3	0
CO5	3	2	2	2	0	0	1	0	0	0	0	0	2	2	0

3: Substantial (High) 2: Moderate (Medium) 1: Poor (Low)

TEXT BOOKS:

1. Irving H. Shames (2006), Engineering Mechanics, 4th Edition, Prentice Hall publications.
2. A Nelson (2009), Engineering Mechanics: Statics and dynamics, Tata McGraw Hill publications.

REFERENCE BOOKS:

1. F. P. Beer and E. R. Johnston (2011), Vector Mechanics for Engineers, Vol I - Statics, Vol II, – Dynamics, 9th Ed, Tata McGraw Hill publications.
2. R.C. Hibbler (2006), Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
3. H.J. Sawant, S.P Nitsure (2018), Elements of Civil Engineering and Engineering Mechanics, Technical Publications.

E-Resources:

1. <https://archive.nptel.ac.in/courses/105/105/105105108/>
2. https://onlinecourses.nptel.ac.in/noc22_ce46/preview
3. <https://www.youtube.com/watch?v=LIZ-PQbGZkA>

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion.
2. Demonstration of solution to a problem through experiential learning.
3. Demonstrations using real objects, taking students on an educational tour.

TECHNICAL ENGLISH [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – I / II	
Course Code : 23EN1107	Credits : 02
Hours / Week : 02 Hours	Total Hours : 26 Hours
L-T-P-J : 2-0- 0-0	
Objective: Developing Communicative competence: Enhancing the Language competence in the technical discourse and augmenting the strategic competence in the social and professional environment.	
Course Learning Objectives: This course will enable students to: a. To enable students to improve their lexical and grammatical competence. b. To enhance their verbal and nonverbal communication in a professional environment c. To optimize oral and written communication. d. To familiarize the students with employability and job search skills. e. To enhance the students with soft skills f. To inculcate critical thinking	
Teaching-Learning Process (General Instructions) These are some of the innovative pedagogical approaches to accelerate the attainment of the various course outcomes. 1. Lecture method: Anecdotes, case studies and Examples from real-life situations may be adopted along with the traditional method of chalk and talk to achieve the course outcome. 2. Interactive Teaching: Active learning may be adopted which includes brainstorming, Teamwork, focused listening, formulating questions, note-taking, and Role play. 3. Collaborative learning through Debates and Group Discussion 4. Activity-based learning to inculcate Critical thinking – conceptualizing, applying, analyzing, synthesizing, and/or evaluating information from observation, perception, and expression. Minimum three higher-order questions from the real-world context 5. Problem-Solving method through Activities and discussion / Minimum of three situations to inculcate Problem-Solving skills and encourage the students to come up with creative ways to solve the problem 6. Audio-visual methods through language Lab in the teaching of LSRW skills. 7. Short films/ Ted talks/ Videos/Animation films to explain the functioning of various concepts. 8. Flipped learning 9. Peer learning / Peer tutoring	
Module – I	06 Hours
Grammar and Usage, Language and Communication. (Branches of Grammar and Vocabulary Word Formation and Types of Word Formation. Communication process diagram. Types of Communication: Managerial, Corporate, Technical and Other Organizational Communication. Barriers to Effective Communication. Listening: Types and their Importance. Difference between hearing and listening. Speaking: Different aspects of Effective Speaking. Oral presentation Pronunciation Guidelines- Common Errors of Pronunciation-Various Techniques for Neutralization of Mother Tongue Influence)	

<u>Objective:</u> - Revising and practicing grammar will help students to optimize their language Competence - Listening steps up language learning and improves pronunciation - Speaking improves one's ability to construct phrases naturally and spontaneously in everyday discussions, Clarity and comprehensiveness in speech. - Communicating effectively in the Professional environment, to interact with the colleagues and to involve in collaborate initiatives	
Module – II	06 Hours
<i>Reading: Extensive and Intensive. Technical Paper Writing and Minutes of the Meeting.</i> <u>Objective:</u> - Reading provides exposure to the chosen field and helps in the coherence of the thought process - Technical writing techniques enable the knowledge in the relevant domain and creates better content based on the need of the target group - Meeting minutes allows to access information such as facts, opinions, votes cast, conflicts, attendees, and other crucial elements at the workplace.	
Module – III	05 Hours
<i>Memo and E-mail Etiquette. Referencing Skills for Academic Report Writing.</i> <u>Objective:</u> - Familiarizing with email etiquettes and correspondence provides learners to form an excellent first impression, establishing trust and confidence. - Following the Academic conventions helps the students to optimize their reference skills and use references to acknowledge the input of other authors and scholars in their work and avoid plagiarism. - Writing technical reports develop competence in creating a legally bound account of efforts and choices and engineering technical report propose a solution to a problem in order to inspire action.	
Module – IV	04 Hours
<i>Group Discussion: Definition, How GD Helps in Student Life & Corporate Life.</i> <u>Objective:</u> GD helps individuals to achieve the skills of organizing and presenting the ideas and concepts in a cohesive manner and to overcome the inhibition of expression in communication	
Module – V	05 Hours
<i>Drafting Curriculum Vitae, Resumes, and Cover- Letters. Job Applications.</i> {Types of Resumes, Preparing Resume, CV and Cover- Letter. Filling Job Application. Difference between Curriculum Vitae, Interview techniques: Telephonic interviews, Group interviews, face-to-face interviews -Mannerism and etiquette}. <u>Objective:</u> Learning the specifics of creating a CV or Resume helps in the effective presentation of their achievements and skills, and a cover letter is a chance for them to exhibit a few aspects of their personality.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Developing language competence improves one's ability to construct phrases naturally in everyday discussions and Communication skills and soft skills enhance the self-confidence of students,	L3
2	Applying the fundamentals of technical writing techniques provides adequate exposure to the respective domain and creates better content. Implementing the technicalities of writing provides better exposure in the domain.	L3
3	Following an appropriate style of email reveals the aspect of professionalism. Develop technical writing skills to increase the quality of the work and testimony of conduct.	L3
4	Practicing communication with greater clarity and ease enable the students to discuss a wide spectrum of topics.	L3
5	Writing resumes or curriculum vitae provides a practice to exhibit their skills and achievements concisely and writing a covering letter enables them to express their personality in the formal context.	L3

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01										2				
C02										2				
C03										2				
C04										2				
C05										2				

TEXT BOOKS:

1. Dhanavel, S.P. "English and Communication Skills for Students of Science and Engineering". Orient Blackswan Pvt. Ltd., 2009.
2. Meenakshi Raman and Sangeetha Sharma. "Technical Communication- Principles and Practice". 3rd Edition, Oxford University Press, 2009.
3. Murphy R. "English Grammar in Use", Cambridge University Press, 2012.
4. N. Krishnaswamy and T. Sri Raman. "Creative English for communication", Macmillan Publication, 2005.

REFERENCE BOOKS:

1. Day. R A. "Scientific English: A Guide for Scientists and Other Professional". 2nd Edition, Hyderabad: Universities Press, 2000.
2. Ashraf Rizvi M. "Effective Technical Communication". McGraw Hill Education, 2017.
3. Eastwood J. "Oxford Practice Grammar". Oxford University Press, 1999.

4. Swan M and Walter C. "Oxford English Grammar Course". Oxford University Press, 2011.
5. Dale, Carnegie. "The Quick and Easy Way to Effective Speaking". JAICO Publishing House, 2019.
6. Chauhan, Gajendra S and Smita, Kashiramka. "Technical Communication". India: Cengage Learning India Private Limited, 2018.
7. Bailey, Stephen. "Academic Writing: A Handbook for International Students". 5th Edition, Routledge, 2017.
8. Kumar, Shiv K and Nagarajan, Hemalatha. "Learn Correct English: Grammar, Composition and Usage". 1st edition, India: Pearson, 2005.
9. Board of Editors. Language and Life: A Skills Approach. Orient BlackSwan, 2018.
10. Sudharshana, NP and C Savitha. English for Engineers. Cambridge University Press, 2018.
11. Kumar, Sanjay and Pushp Lata. English Language and Communication Skills for Engineers. Oxford University Press, 2018.
12. Thomson, A.J. and Martinet, A.V. A Practical English Grammar, OUP, New Delhi: 1986
13. Anne Laws, –Writing Skills||, Orient Black Swan, Hyderabad, 2011
14. Richards, C. Jack. Interchange Students' Book-2 New Delhi: CUP, 2015.

E-Resources:

1. <https://gnindia.dronacharya.info/ME/Common-Subjects/Downloads/Technical-Communication/Books/Technical-Communication-Book-9.pdf>. Web.
2. https://projects.iq.harvard.edu/files/hks-communications-program/files/ho_murphy_michael_pp-slides_9_30_14.pdf. Web.
3. <https://www.youtube.com/watch?v=TR0JZiapxXM>. Web.
4. file:///C:/Users/rochn/Downloads/ManualofEnglishGrammarandComposition_10012575.pdf. Web.
5. <https://www.youtube.com/watch?v=f5Tao6KHV5w>. Web.
6. https://www.sastra.edu/nptel/download/Prof%20GPRagini/pdf_New/Unit%2026.pdf. Web.
7. https://www.hansrajcollege.ac.in/hCPanel/uploads/elearning/elearning_document/English_communication_chapter_13.pdf. Web.
8. <https://www.youtube.com/watch?v=voyGGhlpBR8>. Web.

Activity Based Learning (Suggested Activities in Class)

1. Observing and responding appropriately to the real-life situations.
2. Encouraging students to participate in Group discussions.
3. Articulating internal observations precisely and confidently through extempore.
4. Producing sentences easily without any grammatical errors in speaking, writing essays, and creative writing.
5. Conducting mock interviews, to refine their expressions, familiarize them with the interview techniques, and provide training for the spontaneous response to tricky questions.
6. Directing students for PowerPoint presentations and orienting them towards the higher order skills of expressing their ideas and concepts with cohesion.

ENVIRONMENTAL SCIENCES			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – I/II			
Course Code	: 23EN1108	Credits	: 01
Hours / Week	: 01 Hour	Total Hours	: 13 Hours
L-T-P-J	: 1-0-0-0		
<u>Course Learning Objectives:</u>			
This Course will enable students to:			
1. Understand the concepts of environment, pollution, energy resources Understand basic engineering principles imminently run physiological processes particularly about engineering designs and solutions are arrived citing body functional examples. 2. Learn water as a resource, rain water harvesting as a method of conversation of water. 3. Explain solid waste and its management. 4. Understand environmental Protection Act laws, environmental Impact Analysis and air monitoring			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.			
1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> like power point presentations and group discussion may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three higher order thinking questions in the class. 6. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

COURSE CONTENT:	
UNIT 1: Environment and ecosystem	3 Hrs
Definition of environment; Scope and importance of environmental studies; Basic concepts: Xenobiotic, natural & anthropogenic; why are we concerned? Eco-kinetic & Bio-kinetic Properties of a xenobiotic, Dose-Response Relationships; 3 T's, Chronic and acute effects.	
UNIT 2 : Pollution and management	4 Hrs
Air Pollution: Criteria pollutants – Ozone, Particulate Matter, Carbon Monoxide, Nitrogen, Oxides, Sulphur Dioxide, Lead; Acid Rain Cycle. Water as a resource; Lentic and Lotic Water Systems; Rain Water Harvesting; Water Pollution; Noise pollution-sources and effects of noise; Municipal Solid Waste: Hazardous Waste: Electronic Waste: Biomedical Waste; Solid Waste Management: Landfills, composting Process.	

UNIT 3: Energy	2 Hrs
Energy Types of energy: Conventional sources of energy, fossil fuel, Coal, Solar, wind; Non-conventional Sources of Energy, Biofuels - biomass, biogas.	
UNIT 4: Disaster	2 Hrs
Disasters & Management; Definition, Natural (Earthquakes, landslides, floods), Man-made disasters (biological, chemical, nuclear, radiological explosions) – definition, causes and management and/or mitigation strategies; Bhopal & Chernobyl Disasters.	
UNIT 5: Environmental acts	2 Hrs
Environmental Impact Assessment (EIA); Air pollution monitoring and Ambient Air Quality Standards (AAQS); Environment Protection Act, 1986.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Critically elucidate the basic concepts that govern environmental quality, ambient air quality standards.	L3
2.	Distinguish different Energy resources and their environmental implications	
3.	Distinguish natural and manmade disasters and prevention	L3
4.	Demonstrate different types of pollution and waste streams	L3
5.	Apply the process of environmental impact assessment and implications of Indian Environment Laws	

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion.
2. Demonstration of solution to a problem through experiential learning.
3. Demonstrations using real objects, taking students on an educational tour.

TEXT BOOKS:

1. Benny Joseph (2005). "Environmental Studies", Tata McGraw – Hill Publishing Company Limited, New Delhi.
2. R. J. Ranjit Daniels and Jagadish Krishnaswamy (2014). "Environmental Studies" (2014), Wiley India Pvt Limited, New Delhi.

REFERENCE BOOKS:

1. P. Aarne Vesilind, Susan M.Morgan, Thomson (2008). "Introduction to Environmental Engineering" (2008), Thomson learning, Second Edition, Boston.
2. R. Rajagopalan (2005). "Environmental Studies – From Crisis to Cure" Oxford University Press, New Delhi.

KANNADA KALI			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – I/II			
Course Code	: 23EN1109	Credits	: 01
Hours / Week	: 01 Hours	Total Hours	: 13 Hours
L-T-P-J	: 1-0-0-0		
<u>Course Learning Objectives:</u>			
This course enables students:			
- To introduce Kannada language & culture to Non – Kannada speakers. - To train them to communicate in colloquial Kannada with connivance.			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.			
Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening. - Show Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class.			
UNIT – I			08 Hours
Introduction to Karnataka & Kannada Culture, Evolution of Kannada. Introduction to Kannada Alphabets. Introduction to Kannada Numbers.			
UNIT – II			08 Hours
Kannada words, sentences & phrase making for colloquial communication.			

TEXT BOOKS:

- Kannada Kali –Dr. Lingadevaru Halemane
- Kannada Paatagalu– Editor: Dr. Chandrashekara Kambara.
- SLN Sharma & K Shankaranarayana “Basic Grammar”, Navakarnataka Publications.
- Spoken Kannada. Publication: Kannada Sahitya Parishat Bengaluru.

SINGLE AND MULTI VARIABLE CALCULUS			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – II			
Course Code	: 23EN1201	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-J	: 3-0-0-0		
Course Learning Objectives:			
This Course will enable students to:			
1. Apply sophisticated techniques of differential calculus to solve problems involving functions of multiple variables.			
2. Apply double and triple integrals in various coordinate systems (Cartesian, polar, cylindrical, and spherical) and effectively employ them to calculate areas, volumes.			
3. Acquire a comprehensive understanding of fundamental concepts related to functions of multiple variables, including limits, continuity, and partial derivatives.			
4. Analyze critical points of functions of two or more variables using partial derivatives and Lagrange multipliers, evaluate extreme values.			
5. Apply vector calculus principles, such as line integrals, surface integrals, and the divergence theorem effectively to vector field.			
6. Analyze the convergence and divergence of sequences and infinite series of real numbers by employing various convergence criteria and tests.			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.			
1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes.			
2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.			
3. Show Video/animation films to explain functioning of various concepts.			
4. Encourage Collaborative (Group Learning) Learning in the class.			
5. To make Critical thinking , ask at least three Higher order Thinking questions in the class.			
6. Adopt Problem Based Learning , which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.			
7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I			09 Hours
Differential Calculus			
Functions of two or more variables: Definition, Region in a plane, Level curves, Level surfaces, Limits, Continuity, Partial derivatives, Differentiability, Extreme values and saddle points, Lagrange multipliers. (Textbook 1: Chapter 14: 14.1 – 14.4, 14.7, 14.8)			
Self-Learning Component: Single variable calculus			

UNIT – II		09 Hours
Integral calculus Double integral and iterated integrals - Cartesian and polar coordinates, Triple integral, Change of variables, Multiple integrals in cylindrical and spherical coordinates. (<i>Textbook 1: Chapter 15: 15.1 – 15.5, 15.7</i>)		
UNIT – III		09 Hours
Vector Calculus Line Integrals, Vector Fields, Work, Circulation and flux, Path independence, Potential functions, and Conservative fields, Green's theorem in the plane, Surface area and surface integrals, Surface area of solid of revolution, Parametrized surfaces, Stokes' theorem, The Divergence theorem. (<i>Textbook 1: Chapter 16: 16.1-16.8</i>), (<i>Textbook 2: Chapter 10: 10.1, 10.2, 10.4 – 10.7, 10.9</i>)		
UNIT – IV		6 Hours
Sequence and Series I: Sequences of real numbers and their convergence criteria, Infinite series, Sequence of partial sums, Tests for convergence/divergence - nth term test, Boundedness and monotonicity, Integral, Condensation, Comparison, Ratio and root tests (<i>Textbook 1: Chapter 10: 10.1-10.5</i>)		
UNIT – V		06 Hours
Sequence And Series II: Alternating series, Absolute and conditional convergence, Rearrangement theorem, Power series, Taylor and Maclaurin series (one and two variables). (<i>Textbook 1: Chapter 10: 10.6-10.8</i>)		
Course Outcomes: At the end of the course the student will be able to: Apply the principles of differential calculus to solve problems involving functions of two or more variables. Utilize double and triple integrals in Cartesian, polar, cylindrical, and spherical coordinates to compute areas, volumes, and evaluate mathematical expressions. Extend a comprehensive understanding of the concepts related to functions of multiple variables, encompassing topics such as limits, continuity, and partial derivatives, and effectively apply them to practical situations and problem-solving scenarios. Analyze and evaluate critical points, including extreme values and saddle points, in functions of two or more variables using partial derivatives and Lagrange multipliers. Analyze vector calculus concepts, such as line integrals, surface integrals, and the divergence theorem, in the context of vector fields and their applications. Apply convergence criteria and various tests, such as the nth term test, boundedness and monotonicity, integral, condensation, comparison, ratio, and root tests, to analyze and determine the convergence or divergence of sequences and infinite series of real numbers.		

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1						1					
CO2	3	2	1						1					

C03	3	2	1						1					
C04	3	2	1						1					
C05	3	2	1						1					
C06	3	2	1						1					

3: Substantial (High)

**2: Moderate (Medium)
(Low)**

1: Poor

TEXT BOOKS:

1. Thomas' Calculus, George B. Thomas, D. Weir and J. Hass, 2014, 13th edition, Pearson.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, Wiley India.

REFERENCE BOOKS:

1. Higher Engineering Mathematics, B.S. Grewal, 2015, 43rd Edition, Khanna Publishers.
2. Higher Engineering Mathematics, John Bird, 2017, 6 th Edition, Elsevier Limited.
3. Calculus: Early Transcendentals, James Stewart, 2017, 8 th edition, Cengage Learning.
4. Engineering Mathematics, K.A. Stroud and Dexter J. Booth, 2013, 7 th Edition, Palgrave Macmillan.
5. Basic Multi Variable Calculus, Marsden, Tromba and Weinstein, W.H. Freeman, Third Edition

E-Resources:

1. https://www.youtube.com/playlist?list=PLtKWB-wrvn4nA2h8TFxZWl2zy8O9th_fy
2. <https://www.youtube.com/playlist?list=PLU6SqdYcYsfIqbZvQECrwnlQrp4fg6isX>

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion.
2. Demonstration of solution to a problem through programming.

ENGINEERING PHYSICS [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – I /II			
Course Code	:23EN1110	Credits	: 04
Hours / Week	: 03 Hours	Total Hours	: 39 + 26 Hours
L-T-P-J	: 3-0-2-0		
<u>Course Learning Objectives:</u> This Course will enable students to: 1. To introduce the fundamental ideas of quantum mechanics that are necessary for understanding and addressing engineering challenges. 2. To comprehend solids' band structure, semiconductors' electrical conductivity, and semiconductor devices such as LEDs, photodiodes, and solar cells, as well as their applications. 3. To examine many types of engineering materials, including electronic, electrical, mechanical, and magnetic materials, as well as dielectric material properties and applications in science and engineering. 4. To comprehend various crystal systems and determine structure using miller-indices. 5. Describe thin-film phenomena, thin-film production processes, and applications in science and engineering. 6. To understand how to create Nano materials utilizing a top-down and bottom-up method, as well as to explore Nano science and technology, as well as its practical applications in engineering, biology, and medicine.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 6. Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

SYLLABUS	
MODULE – I	08 Hours
QUANTUM MECHANICS: - Foundations of quantum theory, Wave function and its properties, de-Broglie hypothesis, Heisenberg Uncertainty principle. One dimensional time independent Schrodinger wave equation, Eigen values and Eigen functions. Applications: one dimensional motion of an electron in a potential-well. Basics of Quantum computing - Concepts of Superposition, entanglement, Interference and Qubit. [5 hours] (Text book 1: Chapter 1.5 and Chapter 2 all units) LASER PHYSICS: Introduction to lasers. Conditions for laser action. Requisites of a Laser system Principle, Construction and working of Nd-YAG and Semiconductor Laser. Application of Lasers in Defense (Laser range finder), Engineering (Data storage) and Applications of Lasers in medicine [3 hours] (Text book 1: Chapter 5.1, 5.2, 5.3, 5.4, 5.5)	
MODULE – II	08 Hours
Semiconductor Physics: Band structure, Fermi level in intrinsic and extrinsic semiconductors, Density of energy states in conduction and valence bands of a semiconductor (Mention the expression), Expression for concentration of electrons in conduction band (Derivation), Hole concentration in valence band (Mention the expression), Intrinsic carrier concentration, Conductivity of semiconductors, Hall effect, Numericals. (5 hours) (Text Book-2: Chapter 24.1 to 24.9, Chapter 25.9 to 25.11) Semiconducting devices for optoelectronics applications: - Principle and working of LED, photodiode, Solar cell, BJT [3 hours] (Text Book-2: Chapter 25.1 to 25.8)	
MODULE – III	08 Hours
Dielectrics: Introduction – Dielectric polarization – Dielectric Polarizability, Susceptibility and Dielectric constant - Types of polarizations: Electronic, Ionic and Orientation polarizations (qualitative) – Lorentz Internal field (Expression only) – Claussius - Mossoti equation (derivation) – Applications of Dielectrics – Numericals. (4 hours) (Text book 1: Chapter 4.1, 4.2, 4.3, 4.4, 4.5) Magnetic Materials: Introduction - Magnetic dipole moment - Magnetization-Magnetic susceptibility and permeability - Classification of magnetic materials: Dia, para, Ferro, antiferro & Ferri magnetic materials - Domain concept for Ferromagnetism & Domain walls (Qualitative) - Hysteresis - soft and hard magnetic materials - Engineering applications. Numericals (4 hours) (Text book 1: Chapter 4.9, 4.10, 4.11)	

MODULE – IV		08 Hours
• Crystallography: Lattice, unit cell, lattice parameters, crystal systems, Bravais lattices, Packing fraction for SCC, BCC and FCC crystal systems. Introduction to Miller Indices. Determination of Crystal structure by Miller Indices. Expression for Inter-planar distance. X-ray diffraction, Bragg's law and Determination of Crystal structure by Powder method. Numericals [4 hours] (Text book 1: Chapter 7 all units) • Mechanical Engineering Materials – mechanical properties: stress- strain curve for different materials. Introduction to Tensile strength, Compressive strength, Ductility, Toughness, Brittleness, Impact strength, Fatigue, Creep. Testing of engineering materials: Hardness Tests: Brinell and Vickers hardness test& Numiricals- (4 hours) Text Book-2: Chapter 2.1 to 2.7)		
MODULE – V		07 Hours
• Thin films technology: Introduction to thin-films-Advantages of thin-films over bulk materials. Thin film deposition processes- Physical vapour deposition (Thermal evaporation technique, and sputtering technique) process, Applications of Thin films. [3 hours] (Ref. Text Book-2: Chapter 2. All units) • Nano Science & technology: Introduction to Nano materials, Classification of nano materials, Size dependent properties of materials, Top-down and Bottom-up approach- Ball-milling and Photolithography, Process. Fundamental Principles of Biophysics & Applications of Nano technology in Biology and Engineering. [4 hours] (Text Book-1: Chapter 8.1 to 8.7)		
Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Describe the concepts of Quantum mechanics and applications of Schrodinger time independent wave equation in one dimension.	L1 & L3
2	Illustrate Semiconductors, Semiconductor devices like Photo diode, LED, Solar cell and its applications.	L2 & L3
3	Distinguish the different engineering materials such as Electronic, electrical and mechanical materials properties and their applications in engineering. Apply the concept of magnetism to magnetic data storage devices.	L2 & L3
4	Classify Lattice parameters of different crystalline solids by using X-ray diffraction methods and its applications in science and engineering	L1 & L3
5	Interpret Basic concepts of thin films and thin film deposition processes and their applications leads to Sensors and engineering devices.	L2
6	Categorize Nano materials, Properties, and fabrication of Nano materials by using Top-down and Bottom -up approach's - Applications for Science and technology.	L2 & L3

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2													1
CO2	2													1
CO3	2													1
CO4	1													1
CO5	1											1		2
CO6	3											2		3

3: Substantial (High) 2: Moderate (Medium) 1: Poor (Low)

TEXT BOOKS:

1. P. S. Aithal, H. J. Ravindra, Textbook of Engineering Physics (2011), Acme learning Private Limited, New Delhi, India.
2. Shatendra Sharma, Jyotsna Sharma, Engineering Physics (2019), Pearson, Noida, Uttar Pradesh, India.

REFERENCE BOOKS:

1. M. Young (1977), Optics & Lasers An Engineering Physics approach, Springer
2. K.L. Chopra, Thin film Phenomena, McGraw Hill, New York.
3. S. O. Pillai (2018), Solid State Physics, revised edition, New Age International Publishers, New Delhi
4. M N Avadhanulu, P G Kshirsagar, TVS Arun Murthy (2018), A textbook of Engineering Physics, S Chand, New Delhi.

E-Resources:

1. <https://nptel.ac.in/courses/106/101/106101060/>
2. <http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms>

Activity Based Learning (Suggested Activities in Class)

1. Demonstration of solution to a problem through Project demo model.

ENGINEERING PHYSICS LAB

Total Contact Hours: 26

Following are experiments to be carried out in Engineering Physics Lab

LABORATORY EXPERIMENTS:

List of Experiments:

1.I-V characteristics of a Zener Diode

I-V Characteristics of a Zener diode in forward and reverse bias condition (Module 2)

2. Planck's constant

Measurement of Planck's constant using LED (Module 2)

3.Transistor characteristics

Input and output characteristics of a NPN transistor in C-E configuration (Module2)

4.Dielectric constant

Determination of dielectric constant of a dielectric material (Module 2)

5. Torsional Pendulum

Determination of moment of inertia of a circular disc using torsional pendulum

6. Diffraction grating

Determination of wavelength of a laser light using diffraction grating (Module 4)

7. LCR series and parallel resonance

Study the frequency response of a series and parallel LCR circuit (Module 3)

8. Band gap energy

Determination of energy gap of an intrinsic semiconductor (Module 2)

INTRODUCTION TO ELECTRONICS ENGINEERING [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – I/II			
Course Code	: 23EN1111	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-J	: 3-0-0		
<u>Course Learning Objectives:</u> This course enables students to 1. Understand the fundamental principles of diodes and their applications, including the band diagram of insulators, conductors, and semiconductors, diode construction, and V-I characteristics. 2. Analyze diode circuits under different biasing conditions and comprehend the behavior of diodes in applications such as AND gates, OR gates, rectifiers, and voltage regulators and simulate the same circuits using LTspice software. 3. Comprehend the construction, operation, and characteristics of bipolar junction transistors (BJTs), including input and output characteristics, different biasing techniques, and transistor amplification. 4. Simulate common emitter amplifier circuits with voltage divider bias using LTspice software. 5. Demonstrate an understanding of operational amplifiers (Op-amps), including their symbols, operation modes, properties, and applications such as amplifiers, comparators, and oscillators. 6. Demonstrate an understanding of digital electronics, including binary number systems, Boolean algebra, logic gates, sequential logic circuits, and the application of Flip-Flops. 7. Simulate digital circuits and components using LTspice software. 8. Familiarize themselves with microprocessors and microcontrollers, specifically Arduino boards, and understand their architecture and components. 9. Set up the Arduino development environment, write and upload code to the Arduino board, and execute simple Arduino programs. 10. Interface various sensors and engage in hands-on activities to reinforce understanding, including LED blinking and designing and implementing a complete Arduino-based system as a student project.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class.			

5. To make Critical thinking , ask at least three Higher order Thinking questions in the class. 6. Adopt Problem Based Learning , which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT - I	09 Hours
Diodes and its application: Band diagram of insulators, conductors and semiconductors; semiconductor types: intrinsic and extrinsic (n-type and p-type); overview of diode construction; diode under no-bias, forward bias and reverse bias; V-I characteristics of diode; simplified equivalent circuit of practical diode and ideal diode; overview of diode specifications: peak inverse voltage, reverse leakage current and maximum forward current; numerical on series diode configuration with DC input. Applications: AND gate and OR gate using diodes, half wave rectifier and full-bridge full wave rectifier with smoothing capacitor; simulation of rectifier circuits with smoothing circuit using LTspice software; zener diode: zener region and voltage regulator; numerical on rectifier and voltage regulator. (Textbook 1: Chapter 1: 1.1 to 1.7, 1.9, 1.12, 1.15, Chapter 2: 2.3, 2.5, 2.6, 2.7, 2.11)	
UNIT - II	08 Hours
Transistors: Construction of npn and pnp BJT transistors; transistor operation; input and output characteristics of CB and CE configurations; significance of different regions of operation: active, cut-off and saturation (transistor as a switch); alpha, beta and current relations; transistor amplifying action; numerical on current relations and amplification; Need for biasing: Q-point; types of biasing: fixed, emitter stabilized and voltage divider; simulation of common emitter amplifier with voltage divider bias using LTspice software; numerical on biasing circuits; construction and characteristics of n-channel depletion type MOSFET; (Textbook 1: Chapter 3: 3.1 to 3.5, Chapter 4: 4.1 to 4.5, Chapter 6.1 and 6.7)	
UNIT - III	08 Hours
Operational amplifiers: Op-amp symbols, terminals and operation: single mode, differential mode and common mode; basic properties of ideal and practical Op-amp: input offset voltage, input resistance, output resistance, gain, bandwidth, CMRR, slew rate; basic Op-map applications: inverting amplifier, non-inverting amplifier, summing amplifier, differential amplifier, differentiator and integrator; Op-amp comparator; feedback: positive and negative feedback; criteria for stability and oscillations (Barkhausen criterion); RC phase shift and Wein bridge oscillators; simulation of summing amplifier and oscillators in LTspice software; (Textbook 1: Chapter 10: 10.1, 10.4 to 10.7, Chapter 14: 14.5 to 14.7)	
UNIT - IV	08 Hours
Digital Electronics: Binary number system: conversion and representation; logic levels: high and low; Boolean algebra: operators and DeMorgan's law; logic gates with truth-table and	

representation: AND, OR, NOT, XOR, NAND, NOR; combination of gates and associated numerical; sequential logic circuits: SR latch using NAND/NOR gate, SR FLIP-FLOP, J-K Flip-Flop, D Flip-Flop; application of Flip-Flops: 4 bit binary counter and 4 stage shift register; simulation of counter using LTspice;

(Textbook 2: Chapter 1: 1.1 to 1.3, Chapter 2: 2.1 to 2.5, Chapter 4: 4.1 to 4.3, Chapter 5.1 to 5.5, Chapter 6.1 to 6.4)

UNIT - V	06 Hours
Electronic Prototyping with Arduino: Introduction to microprocessor and microcontrollers (Architecture) , introduction to the Arduino board (UNO, R3) and components; setting up the Arduino development environment; writing and running a simple Arduino program in <i>wokwi</i> environment; introduction to various sensors and actuators compatible with Arduino in <i>wokwi</i> environment; student project: Designing and implementing a complete Arduino-based system.	
E-Resources: 1 and 2	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Demonstrate a solid understanding of the fundamental principles underlying electronic components, such as diodes, transistors, operational amplifiers, logic gates, and microcontrollers.	L2
2	Apply knowledge of electronic components to analyze circuits for various applications, such as rectification, amplification, filtering, and digital logic operations.	L4
3	Analyze the performance of operational amplifiers (Op-amps) in various circuit configurations, including amplifiers, comparators, and oscillators, to optimize their functionality and address design requirements.	L4
4	Demonstrate proficiency in using simulation software (e.g., LTspice) to simulate and analyze electronic circuits, validate designs, and troubleshoot circuit performance.	L4
5	Design and implement electronic systems using Arduino microcontrollers, integrating sensors, actuators, and programming concepts to achieve specific functionalities and solve practical problems.	L6

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1		3							2	3		
CO2	3	3	2	1	3							2	3		
CO3	3	3	2	2	3							2	3	2	
CO4	3	3	2	2	3							2	3	2	
CO5	3	3	3	1	3							3	3	3	

3: Substantial (High)

2: Moderate (Medium)

1:

Poor (Low)

TEXT BOOKS:

1. R. L. Boylestad and L. Nashelsky, "Electronic Devices and Circuit Theory", 11th Ed, Pearson Education, 2013.
2. M. Moris. Mano and Michael D. Ciletti, "Digital Electronics", 4th Ed, Pearson Education, 2006.

REFERENCE BOOKS:

1. David A Bell, "Electronic Devices and Circuits", 5th Ed, Oxford university press, 2008.
2. Millman & Halkias, "Electronics Devices and Circuits", 2nd Ed, McGraw Hill, 2010.

E-Resources:

1. Arduino- <https://docs.arduino.cc/learn/>
2. Wokwi- <https://wokwi.com/arduino/>
3. NPTEL- <https://nptel.ac.in/courses/122/106/122106025>
4. Virtual Labs- <http://vlabs.iitkgp.ac.in/be/>

Activity Based Learning (Suggested Activities in Class):

1. Real world problem solving using group discussion and hands-on activities. E.g., Interfacing different types of sensors using Arduino.
2. Simulation of different electronic circuits. E.g., Rectifiers and Amplifiers.



OBJECT ORIENTED PROGRAMMING			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – II			
Course Code	: 23EN1202	Credits	: 04
Hours / Week	: 05 Hours	Total Hours	: 26(L) + 13(T) + 26(P) Hours
L-T-P-J	: 2-1-2-0		
Course Learning Objectives: This Course will enable students to:			
1. Understand different programming paradigms, significance of object-oriented programming approach and their applications. 2. Make use of Python programming environment to develop programs using conditionals, iterations, functions, strings and files to store and retrieve data in system. 3. Gain skills to develop python programs using core data structures like Lists, Tuples, Sets and Dictionaries. 4. Describe the concepts of object-oriented concept using class, objects, methods. Polymorphism and different levels of inheritance. 5. Explain operator overloading, overriding, single and multiple exception handling capabilities in python.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.			
1. Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 6. Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I			05 Hours

INTRODUCTION TO OBJECT ORIENTED PROGRAMMING AND PYTHON Programming paradigms, Object oriented programming features, applications, merits & demerits, Features of Python, variables, Data types, input operation, Reserved words, Indentation, Expressions, String operations, Type conversions. <i>(Text Book-1: Chapter 2: 2.3,2.4,2.5,2.6 Chapter 3: 3.1,3.6,3.7,3.8,3.10,3.11,3.13,3.14,3.16)</i>	
DECISION AND LOOP CONTROL STATEMENTS: Conditional branch statements, Iterative statements, Nested loops, break, continue, pass, The else statement used with loops. <i>(Text Book-1: Chapter 4: 4.1-4.8)</i>	
UNIT – II	5 Hours
FUNCTIONS AND MODULES: Need for functions, Function definition, Function call, Scope, Return statement, Lambda functions, Recursive functions, Modules. <i>(Chapter 5: 5.1 to 5.11)</i> PYTHON STRINGS: String operations, Immutable, string formatting operator, built-in string methods, string slices, membership operator, comparing strings, Iterating strings. <i>(Chapter 6: 6.1 to 6.9)</i>	
UNIT – III	6 Hours
DATA STRUCTURES IN PYTHON: Sequence, List, Tuple, sets, dictionaries <i>(Chapter 8: 8.1, 8.2, 8.4 to 8.6)</i> FILE HANDLING METHODS: File path, File types, File operations, File positions, Rename and delete files. <i>(Chapter 7: 7.1 to 7.7)</i>	
UNIT – IV	5 Hours
USER DEFINED CLASSES & OBJECTS: Classes, Objects, class method and self Argument, constructor, destructor, class variables, public and private data members, private methods, Calling methods, static methods. <i>(Chapter 9: 9.1 to 9.10, 9.15)</i> INHERITANCE: Introduction, Polymorphism, overriding, types of inheritance <i>(Text Book: Chapter 10: 10.1 to 10.6)</i>	
UNIT – V	5 Hours
OPERATOR OVERLOADING: Introduction, Implementation of operator overloading, Reverse addition, overriding methods and functions. <i>(Text Book: Chapter 11: 11.1 to 11.7)</i> ERROR AND EXCEPTION HANDLING: Errors, Handling exceptions, Multiple except blocks, Multiple exceptions, Except block without exception, The else clause, Raising exceptions, Built-in and user defined exceptions, Finally block, clean-up action <i>(Text Book: Chapter 12: 12.1 to 12.7, 12.10 to 12.12)</i>	

Course Outcomes:

At the end of the course the student will be able to:

1. **Write** a python program using 4 conditionals, definite loop, indefinite loop with jump statements.
2. **Write** an application using lambda, recursive functions, strings and files to store and retrieve the data from the system.
3. **Write python** programs using Core data structures like Lists, Tuples, Sets and Dictionaries.
4. **Implement** the concepts of object-oriented concept using class, objects, methods. Polymorphism and different levels of inheritance.
5. **Implement** operator overloading, overriding, single and multiple exception handling program capability in python

**Table: Mapping Levels of COs to POs /
PSOs**

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	1		2					1				
CO2	3	2	1		2					1		2	1	
CO3	3	2	2		2					1		2	1	
CO4	3	2	2		2					1		2	1	
CO5	3	2	2		2					1		2	1	

3: Substantial (High)

**2: Moderate (Medium)
(Low)**

1: Poor

TEXT BOOKS:

1. Reema Thareja, "Python programming: Using problem solving approach", 2nd Edition, Oxford university press, 2019.

REFERENCE BOOKS:

1. John V Guttag, "Introduction to Computation and Programming Using Python", The MIT press, 3rd edition, 2021.
2. Tony Gaddis, "Starting out with python", 4th edition, Pearson, 2019.
3. Allen Downey, Jeffrey Elkner and Chris Meyers, "How to think like a Computer Scientist, Learning with Python", Green Tea Press, 2014.
4. Richard L. Halterman, "Learning to Program with Python", 2011.
5. Charles Dierbach, "Computer Science Using Python: A Computational Problem-Solving Focus", John Wiley, 2012.

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion.
2. Demonstration of solution to a problem through programming.

OBJECT ORIENTED PROGRAMMINGLABORATORY

Total 26
Hours

List of Programming Experiments:

1. Python Program for Data Handling and Expression Evaluation.
2. Python Program for Quadratic Equation Roots and Number Analysis.
3. Python Program for Function Illustration and Module Creation.
4. Python Program for String Operations and Data Validation.
5. Python Program for File Handling and Script Copying.
6. Python Program for Data Structures and Built-in Methods.
7. Python Program for Object-Oriented Concepts and Inheritance.
8. Python Program for Operator Overloading and Special Methods.

ENGINEERING GRAPHICS & DESIGN THINKING [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER - I/II			
Course Code	: 23EN1112	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 26+26 Hours
L-T-P-J	: 2-0-2-0		
Course Learning Objectives: This Course will enable students to: 1. Create awareness and emphasize the need for Engineering Graphics & design thinking through Manual Sketching & Autocad Software 2. Learn using professional CAD software for construction of geometry 3. Understand the concepts of orthographic and isometric projections 4. Draw orthographic projection of points, lines, planes and solids by Manual Sketching & AutoCad Software 5. Draw development of surfaces of solids 6. Draw isometric projections of planes and solids 7. Create simple engineering 3D components 8. Work in a team for creating conceptual design of products 9. Learn application of design methods and tools on real world problem through Autocad Software & Physical Models			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 6. Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
MANUAL & COMPUTER SKETCHING			
UNIT - I Introduction			06 Hours
Introduction to Engineering Graphics: Fundamentals, Drawing standard - BIS,			

dimensioning, Lines, lettering, scaling, symbols, dimensioning & tolerances, conventions, Introduction to orthographic projection. Types of projections & their principles - (For CIA only) **(For CIA only)**

(Text Book-1: Chapter 3 & 8)

Introduction to Computer Aided Drafting software- Co-ordinate system and reference planes HP, VP, RPP & LPP of 2D/3D. Selection of drawing sheet size and scale. Commands and creation of Lines, coordinate points, axes, polylines, square, rectangle, polygons, splines, circles, ellipse, text, move, copy, off-set, coloring, mirror, rotate, trim, extend, break, chamfer, fillet and curves - **(For CIA only)**

(Text Book-2: Chapter 23 & 24; Text Book-1: Chapter 26)

UNIT – II Projections of Points, Lines and Planes	12 Hours
Projection of Points - Orthographic projections of points in all the quadrants, Orthographic projections of lines - inclined to both the principal planes - Determination of true lengths and true inclinations by rotating line method. Orthographic projections of planes -triangle, square, rectangle, pentagon, hexagon and circular laminae. (First Angle Projection only) (Text Book-1: Chapter 9,10,12)	
UNIT – III Projection of Solids & Development of Surfaces	14 Hours
Projection of regular solids like prisms, pyramids, cylinder & cone inclined to both the planes (change of position method) (First Angle Projection only) (Text Book-1: Chapter 13) Development of lateral surfaces of regular solids – Prisms, pyramids cylinders and cones. (Text Book-2: Chapter 16)	
UNIT – IV Isometric Projections	14 Hours
Isometric projection - Principles of Isometric Projection, Isometric Scale, Isometric View, Isometric projection of combination of two solids (Text Book-1: Chapter 17) Transformation of Projections- Conversion of Isometric Views to Orthographic Views & Conversion of orthographic views to isometric projections. (Text Book-1: Chapter 20; Text book- 2: Chapter 21)	
UNIT – V Introduction to Design Thinking for Innovations	10 Hours
A brief history of Design, Engineering Design process, Product development cycle, creation of models and their presentation in standard 3D view. Theory, Practice & Examples in Design thinking, Storytelling, Creativity and Idea Generation, Concept Development, Testing and Prototyping. (For CIA only) (Text Book-3: Part 1- Chapter 1&2, Part3-Chapter 10)	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Make use of instruments, dimensioning & tolerance principles, conventions and standards related engineering drawing	L1
2	Construct orthographic projections of points, lines, planes and solids	L3
3	Develop lateral surfaces of solids and construct isometric projections of solids	L3
4	Apply the design thinking principles for innovative product development	L3
5	Make use of AutoCad for modelling engineering components	L3

Table: Mapping Levels of COs to POs / PSOs															
COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
C01	2	1	0	0	0	0	0	0	0	0	0	0	3	0	2
C02	2	1	0	0	0	0	0	0	0	0	0	0	3	0	2
C03	2	1	0	0	0	0	0	0	0	0	0	0	3	0	2
C04	2	1	0	0	0	0	0	0	0	0	0	0	3	0	2
C05	3	1	0	0	0	0	0	0	0	0	0	0	3	0	2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor**
(Low)

TEXT BOOKS:

1. Engineering Drawing, Bhatt N.D., 54th Edition, Charotar Publishing House, Gujarat, India, 2023
2. Engineering Drawing & Graphics+Autocad, K Venugopal, Fifth Edition, New Age International Publishers, 2011.
3. Engineering Design- A Project Based Introduction, C. L. Dym and Patrick Little, John Wiley & Sons, 2022

REFERENCE BOOKS:

1. A Textbook of Computer Aided Engineering Drawing, Gopalakrishna, K. R. and Sudheer Gopala Krishna, Subash Publishers, Bangalore, India, 2017
2. Engineering Drawing with Introduction to AutoCAD, Dhananjay .A .J, Tata McGraw-Hill Publishing Company Ltd, 2018
3. Product Design and Development, Karl T Ulrich, Steven D Eppinger, Seventh Edition, McGraw-Hill Education, 2020

E-Resources:

1. <https://archive.nptel.ac.in/courses/112/102/112102304/>
2. <https://nptel.ac.in/courses/112103019>
3. <https://nptel.ac.in/courses/112/105/112105294/>
4. <https://fractory.com/engineering-drawing-basics/>

Activity Based Learning (Suggested Activities in Class)

1. Activity which makes students to apply the concepts learned in the course to the practical engineering graphics will be discussed in class.
2. Activity provides space to students giving responsibility for their own design & engineering drawing methods for the products
3. Activity that makes the students for the development of skill set in computer drafting
4. Activity that makes the students to have critical thinking, developing a mind set, problem-solving and teamwork in design thinking process.
5. Real world problem solving and puzzles using group discussion.
6. Demonstration of solution to a problem through experiential learning.

ENGINEERING GRAPHICS & DESIGN THINKINGLABORATORY

Total Contact Hours: 26

Following are practical/laboratory experiments to be carried out:

1. Problems to be solved in first quadrant system.
2. Manual & Computer Sketching problems for all the modules in sketch book and also take print out of the problems.
3. Usage of various commands in AutoCad software and few simple exercises on the above commands
4. Practice Problems on Projections of Points, Lines and Planes using Manual Sketching & AutoCad Software
5. Solve Problems on Projection of Solids & Development of Surfaces
6. Practice problems on Isometric Projections
7. Individual/Group work on Introduction to Design Thinking for Innovations (Examples on Solid Modeling - Using 3D Modelling Software & Physical Model Prototype).

BIOLOGY FOR ENGINEERS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I/II			
Course Code	: 23EN1113	Credits	: 02
Hours / Week	: 02 Hours	Total Hours	: 26 Hours
L-T-P-J	: 2-0-0-0		
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Acquire an understanding on basic modern biological concepts with an emphasis on how bio-processes are analogous to engineering field, as a multidisciplinary field. 2. Understand basic engineering principles imminently run physiological processes particularly about engineering designs and solutions are arrived citing body functional examples. 3. Explain aspects that many bio-solutions could be foundational to design, develop better processes, products and useful to achieve quality of life.			
<u>Teaching-Learning Process (General Instructions)</u> These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> like power point presentations and group discussion may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three higher order thinking questions in the class. 6. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

COURSE CONTENT:	
UNIT 1 : Biomimetics	5 Hrs
Biology for Engineers, Body Fluid: Blood- Mechanics of heart, Blood pressure, Life molecules: Water, Carbohydrates, Proteins, Lipids and Nucleic acids, Biomimetics: Bio-processes - engineering analogies	
UNIT 2 : Bioenergy	5 Hrs
Unit of life: Human and Plant cell, Metabolism: Enzymes as Bio-catalysts and physiological entities, Anabolism- Bioenergy from Sun-Photosynthesis, catabolism	

UNIT 3 : Biomechanics (Human Body Movement Mechanics)	5 Hrs
Normal Human Movement: Force-Vector of Body; Movement Angles; Muscle contraction - Relaxation; Posture – Static & Dynamic; Ideal and abnormal posture, Practical: Stepping-Lifting-Sit-Stand.	
UNIT 4 : Bioelectronics	6 Hrs
Brain & Computer: Senso-neural networks, Biosensors and IoT as applied to biology, Bionic Eye: Mechanism of Vision, Electronic Nose: Bio-olfactory mechanisms (Science of smell), Impulses: Cardiac and Nerve, Biological Clock and Circadian rhythm	
UNIT 5 : Biopharma	5 Hrs
Metabolic syndromes, Cancer and its diagnostics, Lab on a chip, Drug Discovery	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply and Utilize essential knowledge of the biological mechanisms of living organisms from the perspective of engineers and find solutions to solve bio-engineering problems with appropriate tools.	L3
2	Distinguish and make use of optimal designs in engineering that are bio-mechanical in nature and build and use by observing and understanding bio-physiological processes involved in sensing, locomotion, and knowledge application of range of bio-chemicals.	L3
3	Demonstrate that bio-chemical, bio-sensory, bio-processes could be path-finders to optimise similarities for functional aspects of electronic, computer, mechanical, electrical machines.	L3

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion.
2. Demonstration of solution to a problem through experiential learning.
3. Demonstrations using real objects, taking students on an educational tour.

REFERENCES:

- Campbell, N. A.; Reece, J. B.; Urry, Lisa; Cain, M,L.; Wasserman, S. A.; Minorsky, P. V.; Jackson, R. B. Pearson. "Biology: A global approach", , Global Edition, 10/E, 2014
- David Nelson, Michael Cox. "Lehninger Principles of Biochemistry". W H Freeman & Company, Seventh Edition, 2017.
- Janine M Benvus. "Biomimicry: Innovation inspired by Nature". William Morrow Paperbacks, 2002.
- Lecture Notes, PPT slides by course instructor.

CONSTITUTION OF INDIA AND PROFESSIONAL ETHICS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – I/II			
Course Code	: 23EN1114	Credits	: 01
Hours / Week	: 01 Hours	Total Hours	: 13 Hours
L-T-P-J	: 1-0-0-0		
Course Learning Objectives: This Course will enable students to: 1. Acquaint the students with legacies of constitutional development in India and help those to understand the most diversified legal document of India and philosophy behind it. 2. Make students aware of the theoretical and functional aspects of the Indian Parliamentary System. 3. Channelize students' thinking towards basic understanding of the legal concepts and its implications for engineers. 4. Acquaint students with latest legislation and Laws with related regulatory framework.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 1. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> like power point presentations and group discussion may be adopted to develop the course outcomes. 2. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Show Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, ask at least three higher order thinking questions in the class. 6. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

COURSE CONTENT	
UNIT 1 : Introduction and Basic Information about Indian Constitution	6 Hrs
Meaning of the constitution law and constitutionalism, Historical Background of the Constituent Assembly, Government of India Act of 1935 and Indian Independence Act of 1947, Enforcement of the Constitution, Indian Constitution and its Salient Features, The Sources of Indian Constitution. The Preamble of the Constitution, Fundamental Rights, Fundamental Duties, Directive Principles of State Policy, Parliamentary System, Federal System, Centre-State Relations, Amendment of the Constitutional Powers and Procedure, The historical perspectives of the constitutional amendments in India, Emergency Provisions: National Emergency, President Rule,	



Financial Emergency, and Local Self Government – Constitutional Scheme in India

**UNIT 2 : Union Executive and State
Executive**

7 Hrs

Powers of Indian Parliament Functions of Rajya Sabha, Functions of Lok Sabha, Powers and Functions of the President, Powers and Functions of the Prime Minister, Judiciary – The Independence of the Supreme Court, Appointment of Judges, Judicial Review, Public Interest Litigation, Judicial Activism, LokPal, Lok Ayukta, The Lokpal and Lok ayuktas Act 2013,
State Executives – Powers and Functions of the Governor, Powers and Functions of the Chief Minister, Functions of State Cabinet, Functions of State Legislature, Functions of High Court and Subordinate Court

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Identify and explore the basic features and modalities about Indian constitution.	L1
2	Differentiate and relate the functioning of Indian parliamentary system at the Centre and State level.	L2
3	Differentiate different aspects of Indian Legal System and its related bodies.	L2
4	Discover and apply different laws and regulations related to engineering practices.	L1
5	Correlate role of engineers with different organizations and governance models	L1

TEXT BOOKS:

1. The Indian Constitution, Madhav Khosla, Oxford University Press.
2. The Constitution of India, PM Bakshi. Latest Edition, Universal Law Publishing.

REFERENCE BOOKS:

1. The Indian Constitution: Cornerstone of a Nation (Classic Reissue), Granville Austin, Oxford University Press.
2. Our Constitution: An Introduction to India's Constitution and Constitutional Law, Subhash C. Kashyap, NBT, 2018.
3. Introduction to the Indian Constitution, Brij Kishore Sharma, 8th Edition, PHI Learning Pvt. Ltd.



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SCHEME AND SYLLABUS

B.Tech. PROGRAMME– 2022 BATCH

Definitions / Descriptions

Definition of Credit:	
1 Hour Lecture (L) Per Week	01 Credit
1 Hour Tutorial (T) Per Week	0.5 Credit
1 Hour Practical (P) Per Week	0.5 Credit
1 Hour Project (J) Per Week	0.5 Credit

Course code and Definition:	
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management Courses
IPCC	Integrated Professional Core Course
PCC	Professional Core Courses
PEC	Professional Elective Courses
OEC	Open Elective Courses
SEC	Skill Enhancement Courses
UHV	Universal Human Value Course
PROJ	Project Work
INT	Internship

Implementation of National Education Policy (NEP) 2020 for the B.Tech students of Batch 2022-23

The implementation of Curriculum follows NEP 2020 and addresses the following features and categories of courses:

1. Student Centric flexible curriculum.
2. Inter-disciplinary Courses,
3. Multi-disciplinary Courses,
4. Ability Enhancement Courses,
5. Skill Enhancement Courses,
6. Value Added Courses,
7. Product Design and Development,
8. Internship (Rural Internship, Industry Internship, Research/Development Internship), and
9. Multiple Exit and Multiple Entry
 - Certificate in Engineering after completion of first year.
 - Diploma in Engineering after completion of second year.
 - Advanced Diploma in Engineering after completion of third year.
 - Degree in Engineering after completion of fourth year

SCHEME 2022 - 2026 Batch

Department of Mechanical Engineering

III SEMESTER

III SEMESTER													
S. N	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	BSC	22ME2301	Transforms and Numerical Techniques	MAT	3	0	0	0	03	60	40	100	3
2	IPCC	22ME2302	Engineering Materials	Mech	2	0	2	0	03	60	40	100	3
3	IPCC	22ME2303	Fluid Mechanics and Machines	Mech	3	0	2	0	03	60	40	100	4
4	IPCC	22ME2304	Machining Process and Metrology	Mech	2	0	2	0	03	60	40	100	3
4	PCC	22ME2305	Thermodynamics	Mech	3	0	0	0	03	60	40	100	3
5	IPCC	22ME2306	Computer Aided Machine Drawing	Mech	1	0	4	0	05	60	40	100	3
6	AEC	22LSXXXX	Liberal Studies – I	Any Dept.	1	0	0	0	01	100	--	100	1
7	SEC	22ME23XX	Skill Enhancement Course – I	Mech	1	0	2	0	02	100	--	100	2
			Total		16	0	12	0	23				22

Skill Enhancement Course – I

	Autodesk Innovation Lab		22ME2307
	Bosch Rexroth Innovation Lab		22ME2308

IV SEMESTER													
S. N	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
1	BSC	22ME2401	Probability and Statistics	MAT	3	0	0	0	03	60	40	100	3
2	IPCC	22ME2402	Applied Thermal Systems	Mech	3	0	2	0	03	60	40	100	4
3	PCC	22ME2403	Kinematics and Dynamics ofMachines	Mech	3	0	0	0	03	60	40	100	3
4	PCC	22ME2404	Mechanics of Solids	Mech	3	0	0	0	03	60	40	100	3
5	IPCC	22ME2405	Heat Transfer	Mech	3	0	2	0	02	60	40	100	4
6	IPCC	22ME2406	Machine learning	Mech	2	0	2	0	04	60	40	100	3
7	SEC	22ME2407	Special Topics	Mech	0	0	2	0	01	100	--	100	1
8	SEC	22ME24XX	Skill Enhancement Course – II	Mech	1	0	2	0	02	100	--	100	2
			Total		18	0	10		21				23

Skill Enhancement Course – II			
	Autodesk Innovation Lab		22ME2408
	Bosch Rexroth Innovation Lab		22ME2409

V SEMESTER													
S. N	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	PCC		Microprocessors and Microcontrollers	Mech/EC E	3	0	0	0	03	60	40	100	3
2	PCC		Cloud Computing & Data Processing	Mech/CS E	2	1	0	0	03	60	40	100	3
3	IPCC		Design of Machine Elements	Mech	3	0	2	0	05	60	40	100	4
4	IPCC		Industrial Automation and Robotics	Mech	2	0	2	0	04	60	40	100	3
5	IPCC		Thermal management of Electronic devices	Mech	2	0	2	0	04				3
6	PEC		Professional Elective Course – I/MOOC	Mech	3	0	0	0	03	60	40	100	3
7	SEC		Skill Enhancement Course – III	Mech	1	0	2	0	03				2
			Total		16	0	10	0	26				21

Skill Enhancement Course – III			
	CAE Lab-I (CATIA)		XXXXX
	CAE Lab-II (ANSA)		XXXXX

VI SEMESTER													
S.N	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practica	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	HSMC		Management and Entrepreneurship	Mech/Guest	3	0	0	0	03	60	40	100	3
2	IPCC		Finite Element method	Mech	3	0	2	0	05	60	40	100	4
3	PCC		Mechanical Vibrations	Mech	2	0	2	0	04	60	40	100	3
4	OEC		Open Elective – I	---	3	0	0	0	03	60	40	100	3
5	PEC		Professional Elective Course – II/MOOC	Mech	3	0	0	0	03	60	40	100	3
6	PEC		Professional Elective Course – III	Mech	3	0	0	0	03	100	--	100	3
7	PROJ		Minor Project	Mech	0	0	0	4	04	100	--	100	2
8	INT		Internship	Mech	Completed during intervening period of IV and V sem				--	100	--	100	2
			Total		18	--	2	4	24				23

VII SEMESTER												
S.N	Course Type	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
				Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	J					
1	HSMC	Fundamentals of Economics	Mech	3	0	0	0	03	60	40	100	3
2	IPCC	Instrumentation and Control	Mech	2	0	2	0	03	60	40	100	3
3	OEC	Open Elective – II	--	3	0	0	0	03	60	40	100	3
4	PEC	Professional Elective Course – IV / MOOC	Mech	3	0	0	0	03	60	40	100	3
5	PEC	Professional Elective Course – V	Mech	3	0	0	0	03	60	40	100	3
6	PROJ	Major Project Phase 1	Mech	0	0	0	06	03	100	--	100	3
		Total		16	0	4	6					18

VIII SEMESTER												
S.N	Course Type	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
				Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	J					
1	PROJ	Major Project-Phase 2	Mech	0	0	0	22	03	60	40	100	11
2	INT	Research Internship/ Industry Internship	Mech	0	0	6	0	03	100	--	100	03
		Total										14

NOTE: Total Credits (I-Sem to VIII Sem) = 163 credits.

S.N	Domain-wise	Domain Clusters	PROFESSIONAL ELECTIVE COURSES				
			PEC-I	PEC-II	PEC-III	PEC-IV	PEC-V
			5 th Semester	6 th Semester		7 th Semester	
1	Domain-1	ROBOTICS & AUTOMATION	Sensors & Actuators	Drives & Control systems	Robot Kinematics and Dynamics	Industrial Automation and Control	Robot Manipulators
2	Domain-2	ADDITIVE MANUFACTURING	Automated Manufacturing Systems	Materials for Additive Manufacturing	Processing Of Plastics & Composites	Computational Tools for Additive Manufacturing	Powder Metallurgy
3	Domain-3	HYBRID & ELECTRIC VEHICLES	Introduction to Hybrid & Electric Vehicles	Autotronics	Automotive Chassis & Transmission Systems	Fundamental of Drives and DC Machine Modeling	Advanced Energy Storage
4	Domain-4	RENEWABLE ENERGY	Solar Energy Engineering	Wind and biomass energy	Hydrogen Energy and Storage	Energy management and economics	Energy system modelling and applications
5	Domain-5	General Mechanical Engineering	Refrigeration and Air-conditioning	Micro Electro Mechanical Systems (MEMS)	Total Quality Management	Computational Fluid Dynamics (CFD)	Tool Design

OPEN ELECTIVES:

Open Elective -I (OEC-I)	Open Elective -II (OEC-II)
• Fluids & Thermal Engineering • Materials for Engineering applications • Industrial Robotics	• Automobile Engineering • Total Quality Management and Reliability • Renewable Energy Sources • Rapid Manufacturing Technologies

MINORS DEGREE PROGRAM

Sl. No	Course Name	Credits	Semester
1	Engineering Materials	3	3
2	Mechanics of Solids	3	4
3	Thermal System Engineering	3	5
4	Digital Manufacturing (Theory & Practice)	3	5
5	Product Design and development (Theory & Practice) -	3	6
6	Advances in Mechanical Engineering (Robotics, Electric Vehicle & Green Energy)	3	7
		18	

General Instructions:

- **Open Elective Courses:** At least two courses must be provided from each department and the courses shall be general course on emerging areas with broad coverage of syllabus so that student shall chose without any difficulty.
- **Honors Degree:** An Honors degree typically refers to a higher level of academic achievement in the major area. That is, certificate in his/her OWN major for Research orientation. The Credit requirement: **172 to 178 credits** (Major worth 160 credits + Honors 12 to 18 credits)
- **Minor Degree:** Minor is a secondary concentration of courses that often complements the honors. Minor in any OTHER branch for Improving Employability.
 - Minor is an option rather than a requirement for B. Tech students. They may opt for one of the Engineering or Non-engineering discipline as Minor, earning additional credits ranging from 12 to 18. However, students are permitted to choose only one Minor either from engineering or Non-engineering discipline.
 - This opportunity is ideal for students who took a Major out of necessity but would still like to pursue their passion in another discipline or to enrich/equip them for a specific profession where greater job opportunities exist. Another advantage of opting for a Major with a Minor is to earn standing credits for pursuing a Master's degree abroad or within India too.
 - Only students who satisfy a set of minimum eligibility criteria set forth by the university and meet certain pre-requisites, will be permitted to opt for a Minor.
 - Credit requirement: **172 to 178 credits** (Major worth 160 credits + Minor 12 to 18 credits)
 - Degree nomenclature: The degree will contain the Major / Major with Specialization. The Minor pursued by the student will be provided in the transcript along with details on courses completed and associated credits earned.
 - For e.g., For a student who pursued Computer Science and Engineering with a Minor in Industrial Psychology, the degree will read "B. Tech in Computer Science and Engineering", Transcripts of B. Tech will reflect the Minor courses and the Minor certificate in Industrial Psychology will be issued separately.

TRANSFORMS AND NUMERICAL TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 22ME2301	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-S	: 3-0-0-0		

Course Learning Objectives:

This Course will enable students to:

1. **Apply** their knowledge of Laplace transforms and inverse Laplace transforms to proficiently solve linear ordinary differential equations with constant coefficients, facilitating the analysis and modelling of complex systems.
2. **Analyze** periodic functions using Fourier series, assessing the convergence properties and precision of the series expansion, thereby enhancing their ability to understand and manipulate periodic phenomena.
3. **Utilize** complex exponential form, Fourier transforms of basic functions, and Fourier sine and cosine transforms to solve problems involving Fourier integrals, developing proficiency in applying these techniques to various mathematical scenarios.
4. **Employ** numerical methods, including Euler's Method, Runge-Kutta 4th order, Adams-Bashforth, and Adams-Moulton Methods, to solve differential equations and effectively analyze dynamic systems, enabling them to model real-world phenomena and make accurate predictions.
5. **Apply** finite difference methods, including the Crank-Nicolson method and appropriate techniques for hyperbolic PDEs, to effectively solve different types of partial differential equations (PDEs) such as elliptic, parabolic, and hyperbolic equations, enhancing their problem-solving skills in the context of differential equations and their applications.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I: Laplace Transform and Inverse Laplace Transform	09 Hours
Laplace Transforms of Elementary functions (without proof), (<i>Text Book-1: Chapter 6: 203 to 207</i>). Laplace Transforms of $e^{at}f(t)$, $t^n f(t)$ and $\frac{f(t)}{t}$, Periodic functions, Unit step function and impulse functions (<i>Text Book-1: Chapter 6:208-230</i>). Inverse Laplace Transforms- By the method of Partial Fractions, Logarithmic and Trigonometric functions, Convolution Theorem, Inverse Laplace transform using Convolution Theorem (<i>Text Book-1: Chapter 6: 238</i>). Solution to Differential Equations by Laplace Transform. (<i>Text Book-1: Chapter 238-242</i>).	
UNIT – II: Fourier Series	09 Hours
Periodic Functions, Trigonometric Series (<i>Text Book-1: Chapter 11: 495</i>). Fourier series Standard function, Functions of any Period 2L, Even and Odd functions, Half-range Expansions. (<i>Text Book-1: Chapter 11: 483-492</i>). Practical Harmonic analysis (calculate average power and RMS values of periodic waveforms)	
UNIT – III: Fourier Transform	06 Hours
Calculation of Fourier integrals using complex exponential form (<i>Text Book-1: Chapter 11: 510</i>). Fourier transform of basic functions (<i>Text Book-1: Chapter 11: 510-516</i>). Fourier sine and cosine transforms. (<i>Text Book-1: Chapter 11: 518-522</i>).	
UNIT – IV: Numerical Methods for Solving Ordinary Differential Equations	07 Hours
Euler's Method-Basic principles of Euler's method for solving first-order ODEs (<i>Text Book-1: Chapter 1:10-12</i>). Runge-Kutta 4th order (<i>Text Book-1: Chapter 21:904</i>). Multistep Methods-Explanation of multistep methods (Adams-Bashforth, Adams-Moulton Methods) (<i>Text Book-1: Chapter 21:911-913</i>). Second-Order ODE. Mass-Spring System (Euler Method, Runge-Kutta Methods) (<i>Text Book-1: Chapter 21:916-918</i>).	
UNIT – V: Numerical Methods for Partial Differential Equations	08 Hours
Classification of PDEs (elliptic, parabolic, hyperbolic), (<i>Text Book-1: Chapter 21:922-923</i>). Finite Difference Methods (Laplace and Poisson Equations), Derivation of finite difference approximations (<i>Text Book-1: Chapter 21:923-927</i>). Crank-Nicolson Method (<i>Text Book-1: Chapter 21:938-941</i>). Method for Hyperbolic PDEs (<i>Text Book-1: Chapter 21:943-945</i>).	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply Laplace transforms and inverse Laplace transforms to solve linear ordinary differential equations with constant coefficients, demonstrating proficiency in system analysis and modelling.	L3
2	Analyze periodic functions using Fourier series and evaluate the convergence properties and precision of the series expansion.	L2 & L3
3	Solve problems involving Fourier integrals by applying complex exponential form, Fourier transforms of basic functions, and Fourier sine and cosine transforms.	L3
4	Utilize numerical methods such as Euler's Method, Runge-Kutta 4th order, Adams-Bashforth, and Adams-Moulton Methods to solve differential equations and analyze dynamic systems	L2 & L3
5	Apply finite difference methods, including the Crank-Nicolson method and appropriate techniques for hyperbolic PDEs, to solve various types	L3

	of partial differential equations (PDEs) such as elliptic, parabolic, and hyperbolic equations.													
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	2	2	1					1					
C02	3	2	2						1					
C03	3	2	2	1					1					
C04	3	2	2	1					1					
C05	3	2	2	1					1					
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

TEXT BOOKS:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, Wiley India.

REFERENCE BOOKS:

1. Higher Engineering Mathematics, B.S. Grewal, 2015, 43rd Edition, Khanna Publishers.
2. Higher Engineering Mathematics, John Bird, 2017, 6 th Edition, Elsevier Limited.

E-Resources:

1. <https://nptel.ac.in/courses/111106139>
2. <https://nptel.ac.in/courses/111101164>
3. <https://nptel.ac.in/courses/111105038>

ENGINEERING MATERIALS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 22ME2302	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 26+26 Hours
L-T-P-S	: 2-0-2-0		

Course Learning Objectives:

This course will enable students to:

1. **Analyse** the atomic/molecular structure difference between crystalline and non-crystalline materials.
2. **Determine** the tensile, compression, shear, and bending deformations of the metal specimen and describe the changes in specimen profile up to the point of fracture.
3. **Explain** the various phases present, composition, and mass fractions of the phases from a binary phase diagram.
4. **Understand** the types and applications of ceramics and polymers.
5. **Learn** the different manufacturing processes for composite materials.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I	05 Hours
INTRODUCTION TO MATERIALS: Introduction to materials, Overview of Crystal Structure, Solid Solutions, Hume Rothery Rules, Crystal Imperfections, Critical nucleus size, and Critical Free Energy. <i>(Text Book-1: Chapter 3: 3.1 to 3.7)</i> CRYSTALLIZATION: Mechanism of Crystallization, Nucleation, Nucleation- Growth, Single crystal, Polycrystalline Materials, Basic principles of solidification of metals and alloys. Solidification time, Cooling curves, Non- crystalline solids. functions <i>(Text Book-1: Chapter 3: 3.8, 3.17)</i>	
UNIT - II	05 Hours
TESTING OF MATERIALS: Testing of materials under tension, compression, and shear loads, Hardness tests, fatigue, and creep test. Impact testing. <i>(Text Book-1: Chapter 6: 6.6 to 6.11)</i> FATIGUE AND FRACTURE TEST: Fatigue testing, Fracture, Types, Fracture mechanics. Characteristics of creep curve & steady-state creep. Fracture toughness & fatigue, Stress, and temperature effects. <i>(Text Book-1: Chapter 8: 8.1 to 8.11)</i>	
UNIT - III	06 Hours
EQUILIBRIUM PHASE DIAGRAMS: Particle strengthening by precipitation. Precipitation reactions. Phase Rule, Unary System, Binary Phase diagrams, and Iron-carbon system. <i>(Text Book-1: Chapter 9: 9.1 to 9.6)</i> PHASE TRANSFORMATIONS. Transformation rate effects and Isothermal transformations (TTT Curves), Continuous cooling transformations, Microstructure and property changes in the iron-carbon system, Iron-carbon equilibrium diagram, and Heat treatments. <i>(Text Book-1: Chapter 9: 9.17 to 9.20, Chapter 11: 11.8 to 11.9)</i>	
UNIT - IV	05 Hours
STEEL AND MATERIAL PROPERTIES: Classification of steels and cast iron, Microstructure, Effect of alloying elements on steel, Ferrous alloys, and their applications, High Resistivity and High-temperature alloys, Selection of material for various applications- case studies. <i>(Text Book-1: Chapter 24: 24.1 to 24.3)</i> CERAMICS: Ceramics, Glass Ceramics, Advanced Ceramics, Functional properties and applications of ceramic materials and Glasses. <i>(Text Book-1: Chapter 12: 12.1 to 12.11)</i>	
UNIT - V	05 Hours
OPTICAL PROPERTIES OF MATERIALS Electromagnetic radiation, light interaction with solids, atomic and electronic interaction, refraction, reflection, and absorption. <i>(Text Book-1: Chapter 21: 21.1 to 21.7)</i> Light-emitting diodes, lasers, and optical fibers in communication <i>(Text Book-1: Chapter 21: 21.13, 21.14)</i>	
LAB COMPONENT	
1. Tension Test- To understand the tensile characteristics of mild steel through tensile testing and thereby determine mechanical properties such as ultimate tensile strength, elastic modulus, proportionality limit, yield point, fracture stress, percentage elongation & reduction in area. 2. Compression Test- To determine the compressive strength of aluminium and cast-iron specimens and to identify the failure modes of ductile/brittle materials through evaluation of their failure modes of the above material.	

3. Shear Test - To determine the ultimate shear strength of aluminium under single and double shear.
4. Bending Test - To investigate the relationship between load and span on the deflection of a simply supported beam subjected to a concentrated load at the center. Also, evaluate the modulus of elasticity of the given beam from the test data.
5. Impact Test (Charpy and Izod) - To evaluate the energy absorbed during failure of a notched specimen subjected to pendulum impact testing.
6. Brinell hardness Test -To determine the Brinell Hardness Number (BHN) of the given specimens.
7. Vicker's Hardness Test - To determine Vickers Hardness Number for a given specimen.
8. Wear Test - To understand the parameters that affect the wear rate using pin and disc apparatus.
9. Composite preparation- preparation of polymer composites through hand lay-up, vacuum bagging, and resin transfer molding process.
10. Demonstration of 3D printing of given polymer/metal/ceramic specimens

Course Outcomes:

At the end of the course, the student will be able to:

- Classify engineering materials based on their crystal structure
- Calculate the material properties through testing of materials
- Interpret phase diagram for alloy preparation
- Analyze the phase diagram, microstructure and the mechanical properties of materials
- Select material for an application by analyzing the requirements with the material properties
- Develop polymer composites by hand lay-up, vacuum bagging, resin transfer molding and filament winding processes

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	1
C02	3	3	3	3	3								2	1
C03	3	3	3	3	2								2	1
C04	3	3	3	3	3								2	1
C05	3	3	3	3	3								2	1
C06	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. William D. Callister, Jr. (2020) "Materials Science and Engineering an Introduction", 2nd Edition, John Wiley & Sons, Inc.
2. V. Raghavan (2019), "Materials Science and Engineering", Prentice–Hall of India Pvt. Ltd

REFERENCE BOOKS:

1. J.M. Shackelford (2014), Introduction to Materials Science for Engineers, 5th Edition, Prentice Hall, Inc.
2. Suryanarayana, A. V. K. (2020), Testing of Metallic Materials, Prentice Hall India, New Delhi.
3. W. Bolton (2013), Engineering materials technology, 3rd Edition, Butterworth & Heinemann.

E-Resources:

1. <https://nptel.ac.in/courses/113107078>
2. <https://nptel.ac.in/courses/103105219>
3. <https://nptel.ac.in/courses/112107221>
4. <https://www.coursera.org/learn/crystal-structures-and-properties-of-metals?>

Activity-Based Learning (Suggested Activities in Class)

1. Real-world problem-solving and puzzles using group discussion. E.g. material identification, microstructure study of materials using an Optical microscope, etc.,
 2. Demonstration of the fabrication of material using different techniques like stir casting, Hand layup, etc.
-

FLUID MECHANICS AND MACHINES [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – III			
Subject Code	: 22ME2303	Credits	: 04
Hours / Week	: 05 Hours	Total Hours	: 39+26 Hours
L-T-P-S	: 3-0-2-0		
Course Learning Objectives: This Course will enable students to: 1. Define basic properties of fluids and understand the continuum approximation. 2. Describe Lagrangian and Eulerian Approach for fluid flow Buckingham's Pi theorem 3. Apply dimensional analysis to design new pumps or turbines that are geometrically similar to existing pumps or turbines 4. To study the performance parameters of Impulse and Reaction turbines like Pelton wheel turbine, Francis turbine and Kaplan turbine 5. To study the performance parameters of Reciprocating, Centrifugal and Gear pumps			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I			08 Hours
Fluid Properties and Fluid Statics Introduction, properties of fluids, viscosity, thermodynamics properties, surface tension and capillarity, vapour pressure. Types of fluid flows Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmospheric and vacuum pressures, Fluid Statics: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid. (Text Book-1: Chapter 1: 1.1 to 1.2)			
UNIT – II			08 Hours

Fluid Kinematics and Dynamics Lagrangian and Eulerian Approach for fluid flow, Continuity equation Velocity and acceleration in a flow field, Potential and stream function, Fluid Dynamics Introduction, Equation of motion, Euler's equation of motion, and Bernoulli's equation derived from fundamental & Euler's equation, Bernoulli's equation for real fluids. Fluid Flow measurements- Venturimeter, orifice meter and Pitot tube. Flow through Pipes-Major & Minor losses in pipe flow. Numerical exercise. of large integers, (Text Book-2: Chapter 7: 7.1 to 7.6)	
UNIT - III	06 Hours
Dimensional Analysis and Boundary Layers Introduction, Dimensional homogeneity -Buckingham theorem - Non-dimensional numbers - Model laws; Unit Quantities and Specific quantities, introduction to boundary layer theory -Laminar flow and Turbulent flow - Boundary layer thickness. (Text Book-2: Chapter 7: 7.2 to 7.3)	
UNIT - IV	09 Hours
Hydraulic Turbines Euler's Turbine equation, Classification of turbines, Impulse and reaction turbines, Pelton wheel, Francis and Kaplan turbine -work done and efficiencies. Draft tube theory, Performance of hydraulic machines, unit and specific quantities, turbine governing. The Knapsack problem (Text Book-2: Chapter 9.1: 9.6).	
UNIT - V	08 Hours
Pumps Classification, working, work done - monometric head- losses and efficiencies- specific speed- pumps in series and parallel-performance characteristic curves, NPSH. Reciprocating pumps: Working, Discharge, slip. (Text Book-2: Chapter 14: 14.1, 14.7)	
Course Outcomes: At the end of the course the student will be able to: • Categorize the fluids based on rheological behavior and also calculate the pressure, velocity and acceleration at a point in a static as well as fluid under motion • Apply Bernoulli's equation for a real fluid flowing between two sections for various engineering applications like measurement of discharge and estimation of losses • Develop non-dimensional groups for a physical phenomenon dependent on number of variables and also predict different flow regimes possible in case of a fluid -solid interaction based on critical Reynold's number • Calculate the power produced/ consumed and efficiencies obtained from a turbine/pump based on the velocity triangles • Compute the discharge, losses in a pipe flow and performance of hydraulic machines by conducting experiments	
List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs`	
1. Rotameter Calculation of the Rate of Flow Using Rotameter	
2. Venturimeter Determination of the Co- Efficient of Discharge of the Venturimeter	
3. Orifice Meter	

Determination of the Co-Efficient of Discharge of the Given Orifice Meter	
4. Pipe Friction	Determination of frictional loss in a pipe flow
5. Pipe Fittings	Determination of Loss of Head on Pipe Fittings
6. Notch	Determination of Co- efficient of Discharge of the Given Notch
7. Centrifugal Pump	Study of Performance Test On Centrifugal Pump
8. Reciprocating Pump	Study of Performance Test On Reciprocating Pump
9. Gear Pump Test Rig	Study of Performance Test On Gear Pump
10. Pelton Wheel Turbine	Study of Performance Test on Pelton Wheel Turbine
11. Francis Turbine	Study of Performance Characteristics Curves of Francis Turbine

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	1	1	1	1	1	1	1	1	2	2	3
CO2	3	3	2	2	1	1	1	1	1	1	1	2	2	3
CO3	3	2	2	1	2	1	1	1	1	2	1	2	3	3
CO4	2	3	2	2	1	1	1	1	2	2	2	2	3	3
CO5	2	2	3	3	2	1	1	1	3	3	3	3	2	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

TEXT BOOKS:

1. Jagdish Lal, Hydraulic Machines, Metropolitan Company book company Limited, 2016.
2. Yunus A.Cengel, John M.Cimbala Fluid Mechanics– Fundamental and Applications, Tata McGraw-Hill Publishing Co. Ltd, 2006.

REFERENCE BOOKS:

1. Bruce R. Munson, Donald F. Young, Theodore H. Okiishi, Wade W. Huebsc (2009)
2. Fundamentals of Fluid Mechanics, John Wiley & Sons Publications.Frank M White (2011),

E-Resources:

5. <https://open.umn.edu/opentextbooks/textbooks/85>
6. <https://library.iitd.ac.in/index.php/node/81851>
7. <https://www.constructionplacements.com/books-on-fluid-mechanics/>
8. <https://searchworks.stanford.edu/view/11842972>

<u>Machining Process and Metrology</u> [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – III	
Subject Code : 22ME2304	Credits : 03
Hours / Week : 04 Hours	Total Hours : 26+26 Hours
L-T-P-S : 2-0-2-0	
<u>Course Learning Objectives:</u> This Course will enable students to: - Understand the basic fundamentals and mechanics of metal cutting, tool geometry and life. - Explain the basic knowledge of various non-traditional machining processes - Impart knowledge on CNC machining operation - Describe and illustrate the concept of slip gauges and wringing phenomenon and Study on different types of mechanical and electrical compactors - Study the limits, fits, tolerances and gauges.	
<u>Teaching-Learning Process (General Instructions)</u> These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. - Show Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, ask at least three Higher order Thinking questions in the class. - Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. - Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I MODULE 1: Theory of Metal Cutting	05 Hours
Types of cutting tool materials, cutting fluids, Single & Multi point cutting tool nomenclature, orthogonal and oblique cutting, mechanism of chip formation, types of chip, merchant analysis, Ernst-merchant's solution, shear angle relationship, problem of merchant's analysis, tool wear and tool failure effects of cutting parameters, tool life criteria, Taylor's tool life equation, problems. . (Text Book-1: Chapter 1: 1.1 to 1.2)	
UNIT – II: Non-Traditional Machining Processes	05 Hours

Introduction, Classification, Abrasive jet machining, Ultrasonic machining, Water jet machining, Abrasive Water Jet Machining, Electro chemical machining, Electro Chemical Grinding, Electro-discharge machining, Laser beam machining, Electron Beam Machining, Chemical Milling, Photochemical Milling process characteristics – applications, advantages and disadvantages.	
UNIT – III: Computer Numerical Control & Part Programming	06 Hours
Fundamentals of numerical control, advantages & classification of NC systems, Functions of MCU, principles of operation features, functions of CNC, Manual part programming, Codes and concepts, point to point and contour programming examples, 2-D simple problems of Drilling, Turning and Milling.	
UNIT – IV: Standards of Measurement in Metrology	06 Hours
Concept of metrology, role of standards, and standards of length Principles, calibration of standards, numerical problems, and slip gauges, set of gauges, wringing phenomena, manufacture of slip gauges. Numerical problems on building of slip gauges, Errors in measuring instruments, classification of errors, sources of errors and uncertainty. Comparators - mechanical, electrical, pneumatic and optical comparators Advances in Metrology Basic concept of lasers, laser Interferometers. Basic concept of CMM, Types of CMM.	
UNIT – V : System of Limits, Fits, Tolerance and Gauging	04 Hours
Indian standards, concept of limits of size and tolerances, interchange ability, selective assembly definition of fits, hole basis system, shaft basis system, types of fits and their designation, geometric tolerance. Classification of gauges, brief concept of design of gauges (Taylor's principles), Numerical problems.	
List of Laboratory/Practical Experiments activities to be conducted : 26 Hrs	
1. To Study Construction, Working and Performing Operations on a Lathe, Drilling, Grinding & Shaping Machine	
2. To study tool wear and tool life measurements for machinability	
3. Introduction of Computer Numerical Control Machines and working of few Models on CNC machine.	
4. Calibration of Micrometer, Vernier caliper, Thermocouple, Linear Variable Differential Transformer (LVDT), Load Cell To calibrate and measure the given component by using Micrometer, Vernier caliper, Thermocouple, Linear Variable Differential Transformer (LVDT), Load Cell	
5. Measurements using Optical Profile Projector, Toolmaker's Microscope To measure the screw thread parameters of a given specimen using Optical Profile projector & Tool Maker's Microscope	
6. Measurements of angle using Sine bar & universal bevel protractor To determine the unknown angle of the given specimen using sine bar with the help of slip gauge & universal bevel protractor	
7. Measurements of Screw thread parameters using two wire or three-wire methods - To find the effective diameter of a given screw thread by two or three wire method.	
8. Measurements of gear tooth profile using gear tooth Vernier caliper - To Measure the tooth thickness of the given gear using Gear Tooth Vernier Caliper	
9. Study the mechanism and working of 3D Printing machine	

Course Outcomes:

At the end of the course the student will be able to:

- Select an appropriate machine tools for various machining operations
- Compare the non-traditional machining processes for advanced machining applications
- Illustrate working of CNC machine and perform part programming for 2D milling, and drilling operations
- Apply measurement standards and system, Comparators and Slip gauges to calculate related errors during measurements.
- Calculate tolerance, limits of size, fits, gauges and the various design concepts in gauging

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	1	1	1	1	1	2	2	2	2	3	3
C02	2	3	3	2	1	1	1	1	2	2	1	2	3	3
C03	2	2	3	2	3	1	1	1	2	2	2	2	3	3
C04	2	2	2	2	2	1	1	1	2	3	3	2	2	3
C05	2	2	2	2	2	1	1	1	2	3	3	2	2	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. P.N. Rao (2018) "Manufacturing Technology – Metal Cutting and Machine Tools," Volume-II, 4 Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi.
2. R.K. Jain (2009), Engineering Metrology, Khanna Publishers, New Delhi.

REFERENCES:

1. M. P. Groover (2019), "Fundamentals of Modern manufacturing" -materials, processes and systems Third Edition, Wiley publications, 7th Edition.
2. Kaushik Kumar, Chikesh Ranjan and Paulo Davim (2020) CNC Programming for Machining, Springer International Publishing.
3. Ernest O. Doebelin (2019), Measurement Systems: Application and Design, SIE Publications
4. Beckwith Marangoni and Lienhard (2006), Mechanical Measurements, Pearson Education, 6th Edition

E-Resources:

Activity Based Learning (Suggested Activities in Class)

3. Real world problem solving and puzzles using group discussion. E.g., Fake coin identification, Cabbage puzzle, Konigsberg bridge puzzle etc.,
4. Demonstration of solution to a problem through programming.

THERMODYNAMICS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – III	
Subject Code : 22ME2305	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Introduce basic concepts related to thermodynamic system 2. Understand Zeroth law of thermodynamics as basis for temperature measurement. Define first law of thermodynamics as applied to a closed and open systems 3. Explain working of heat engine and refrigeration cycles and to define second law of thermodynamics: Kelvin Planck and Clausius Statement. 4. Understand the property entropy through Clausius inequality 5. Understand behaviour of ideal and real gases through equation of state and compressibility factor.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours
INTRODUCTION: Basic Concepts of Thermodynamics: Introduction- Basic Concepts, Thermodynamic Equilibrium, Thermodynamic properties, Thermodynamic state, state point, path and process, quasi-static process, cyclic and non-cyclic processes, Energy and its forms, Work and heat (sign convention), Zeroth Law of Thermodynamics: Zeroth law of thermodynamics statement, Concept of Temperature and its' measurement. (Text Book-1: Chapter 1: 1.1 to 2.11)	

UNIT - II	08 Hours
First law of thermodynamics: Application to closed and open system, Joules experiments, equivalence of heat and work, Internal energy and enthalpy, energy as a property, specific heat at constant pressure and volume, PMM1, steady state, steady flow energy equation (SFEE), extension of first law to control volume, Limitations of first law of thermodynamics, Extension of SFEE to Various devices like-nozzle, turbine , pump/compressor, heat exchanger <i>(Text Book-1: Chapter 4: 4.1 to 5.4)</i>	
UNIT - III	06 Hours
Second Law of Thermodynamics: Thermal reservoirs, , devices converting work to heat in a thermodynamic cycle, heat engine, Efficiency reversed heat engine, heat pump, Refrigerator, Coefficient of Performance, Kelvin-Planck and Clausius statement of second law of thermodynamics, Equivalence of the two statements, reversible and irreversible processes, factors that make a process irreversible, Carnot cycle and Carnot engine, Carnot theorem and its corollaries. <i>(Text Book-1: Chapter 6: 6.1 to 6.18)</i>	
UNIT - IV	08 Hours
Entropy: Classius Inequality:- Statement, proof, application to a reversible cycle, Entropy: Definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility, Tds equation, calculation of entropy using TdS relations, entropy as a coordinate, Exergy(Available) and unavailable energy, Second law efficiency. <i>(Text Book-1: Chapter 7: 7.1 to 7.18)</i>	
UNIT - V	09 Hours
Pure substance: Phase change process in a pure substance, Definition of triple, ice, steam and critical points, Property diagrams of pure substance, p-v, p-T, p-h, T-v, T-s diagrams, dryness fraction, use of steam tables. <i>(Text Book-1: Chapter 9: 9.1 to 9.8)</i> Ideal and Real Gases Gas laws- Boyle's Law, Charles Law ,Gay-Lussac Law, Avogadro's law, equation of state - Vander Waals, Redlich-Kwong, Peng- Robinson etc. compressibility factor. <i>(Text Book-1: Chapter 10: 10.1 to 10.19)</i>	
Course Outcomes: At the end of the course the student will be able to: • Apply laws of thermodynamics in temperature measurement and also calculate work and heat interaction of system with the environment • Analyze closed and open system performance using second law of thermodynamics • Calculate entropy change of a system and surrounding by undergoing a thermodynamic process • Estimate the maximum work potential of energy source based on the laws laid down by thermodynamics • Calculate thermodynamic properties of a pure substance in a given state	

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	2
C02	3	3	3	3	3								2	2
C03	3	3	3	3	2								2	2
C04	3	3	3	3	2								1	1
C05	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

- P.Nag (2017), Basic & Applied Thermodynamics, 2nd Edition, Mc Graw Hill Education.
- Van Wylen, G.J., and Sonntag, R.E., (2002), Fundamentals of Classical Thermodynamics for Engineers, 6th Edition, Wiley.

REFERENCE BOOKS:

1. Yunus A Cengel and Michael A Boles (2017), Thermodynamics: An Engineering Approach, McGraw Hill Education.
- Michael J. Moran, Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd, Chichester.

E-Resources:

- <https://nptel.ac.in/courses/102106026>
- <https://www.classcentral.com/course/edx-thermodynamics-of-materials-21137>
- <https://www.askiitians.com/iit-jee-thermal-physics/introduction-to-thermodynamics/>
- <https://www.coursera.org/learn/thermodynamics-intro>

Activity Based Learning (Suggested Activities in Class)

- Use of simulations and modelling software to explore complex thermodynamic systems and see how changes in variables affect the overall behaviour of the system. For example, students could use a simulation to explore how changes in pressure and temperature affect the behaviour of a gas.
- Experiments can help students visualize and experience the concepts they are learning about in class. For example, students could conduct experiments to measure the specific heat capacity of different materials or to observe phase changes in different substances.

COMPUTER AIDED MACHINE DRAWING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 22ME2306	Credits	: 03
Hours / Week	: 05 Hours	Total Hours	: 65 Hours
L-T-P-S	: 1-0-0-4		

Course Learning Objectives:

The objectives of the Course are to:

1. **Provide** overview of various CAD software
2. **Learn** basics of sketching features
3. **Create** 3D models using extrude, revolve, draft & other advanced options
4. **Introduce** assembly concepts
5. **Create** simple & complex mechanical assemblies
6. **Create** industrial standard drawings with appropriate views including sectional views

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

Lecture method means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.

Interactive Teaching: Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.

- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I CAD OVERVIEW

05 Hours

CAD OVERVIEW:

Preferences-Settings, User Interface- Familiarize the User Interface by creating a simple design Familiarize The User Interface of Fusion 360 (Toolbar, Marking Menu, Browser, And Time Line Controls, Change of Workspace) Familiarize the User Interface of FUSION 360 (Navigations and data panel interface, Design Units and Origin, Quick Shape Creation) Use of toolbar, marking menu, browser and time line controls, change of workspace, Navigations and data panel interface, Design Units and Origin, Quick Shape Creation.

(Text Book-1: Chapter 1)

UNIT – II SKETCHING WORKSPACE		10 Hours
SKETCHING WORKSPACE: Sketching Workspace: Creating a sketching geometry - Introduction to the Sketching Workflow Sketch Entities, <i>(Text Book-1: Chapter 2)</i> Dimensioning, Sketch Constraints. <i>(Text Book-1: Chapter 3)</i> Additional Sketching Tools- Additional Entity Types, Editing Tools, Additional Dimension Tools, Moving and Copying, Rectangular and circular Patterns. Sketched Secondary Features using existing geometry. Pick and Place Features- Fillets, Chamfers, Holes, Editing Pick and Place Features. Construction of planes, axis and points, creating a sketch using Equation and Parameters. <i>(Text Book-1: Chapter 4)</i>		
UNIT – III SOLID MODELLING		15 Hours
SOLID MODELLING Introduction-Solid Modelling Basic Part modelling features- Extrude and revolve. Additional Features and Operations- Draft, Shell, Rib, Split Face, Scale, Thread, Press Pull. Direct Modelling Development of multi section solids and sweep. Feature Duplication – mirroring and patterning. <i>(Text Book-1: Chapter 5, 6 & 7)</i> Design and Display Manipulation- Reordering, inserting, suppressing Features, Measure and Section Analysis, Develop the part models and prepare the drafting. List out the operations involved to prepare the components. <i>(Text Book-1: Chapter 8, 9 & 10))</i>		
UNIT – IV ASSEMBLY		15 Hours
ASSEMBLY Distributed Design- Assembly Design Methods, Joint Origins and Assigning Joints. Component Design Tools- Rigid Groups, Interference Detection Multi-Body Design- Multi- Body Design Tools, Components, As-Built Joints <i>(Text Book-1: Chapter 11& 12)</i> Drawing Basics-Creating a New Drawing, Additional Drawing Views, Exploded Views, Manipulating Drawings. Detailing Drawings- Dimensions, Parts List and Balloons, Annotation and Dimension Settings, Drawing Output. Data exchange standards – IGES, STP, STL, STEP etc <i>(Text Book-1: Chapter 14))</i>		
UNIT – V MACHINE ASSEMBLY		20 Hours
MACHINE ASSEMBLY Develop the assembly drawing from the given detailed drawing (Swivel bearing) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly <i>(Text Book-2: Chapter 18: 18.5.8)</i> Develop the assembly drawing from the given detailed drawing (steam engine connecting rod end) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly <i>(Text Book-2: Chapter 19: 19.2)</i> Develop the assembly drawing from the given detailed drawing (Pressure relief valve) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly <i>(Text Book-2: Chapter 18: 18.4.8)</i>		

Develop the assembly drawing from the given detailed drawing (Machine vice) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.3.9)

Develop the assembly drawing from the given detailed drawing (Tailstock) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.3.5)

Develop the assembly drawing from the given detailed drawing (Piston of a petrol engine) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.2.6)

Develop the assembly drawing from the given detailed drawing (Air valve) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.2.10)

Develop the assembly drawing from the given detailed drawing (Fuel Injector) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.2.11)

Develop the assembly drawing from the given detailed drawing (Speed reducer) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.5.15)

Develop the assembly drawing from the given detailed drawing (Drill jig) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.3.11)

Course Outcomes:

At the end of the course the student will be able to:

- Compare the functionality of different tools and features within Fusion 360 for machine assembly requirements.
- Apply simple and advanced sketching tools and features in Fusion 360 to create precise and complex 2D sketches, considering appropriate sketch entities, dimensions, and constraints.
- Utilize design constraints and parameters in Fusion 360 to create parametric 3D models, allowing for modification and adaptation of empirical relations.
- Assess the machine assembly models in Fusion 360, identifying any potential interferences, clashes, or design issues.
- Develop precise and professional manufacturing drawings with appropriate dimensions, annotations, and GD&T symbols using Fusion 360 tools.

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	2	1	1	1	2	2	2	2	3	3	3
CO2	3	3	3	2	3	1	1	1	2	2	1	2	3	3	3
CO3	3	3	3	2	3	1	1	1	2	2	1	2	3	3	3
CO4	3	3	3	3	3	1	1	1	3	3	2	2	3	3	3
CO5	3	3	3	2	3	1	1	1	2	3	3	2	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXTBOOKS:

1. Autodesk Fusion 360: A Power Guide for Beginners and Intermediate Users, John Willis, Sandeep Dogra, Cadartifex. Createspace Independent Publishing Platform, USA, 2018.
2. Machine Drawing, K. L. Narayana, P. Kanniah, K. Venkata Reddy, 5th Edition, New Age International Publishers, Newdelhi, 2016.

REFERENCE BOOKS:

1. Machine Drawing in First angle projection, K. R. Gopalakrishna, Subhas publication, Bangalore, 2017.
2. Machine Drawing, N.D. Bhat & V.M.Panchal, Charotar Publishing House., 2016.

E-BOOKS / ONLINE RESOURCES/VIRTUAL LABS:

1. <https://www.gutenberg.org/ebooks/39033>

MOOC:

1. <https://www.coursera.org/learn/fusion-360-integrated-cad-cam-cae>

Activity Based Learning (Suggested Activities in Class)

1. Activity which makes students to apply the machine drawing concepts learned in the course during the drafting of 3D machine parts and its assembly using CAD tool, will be discussed in class.
2. Activity that makes the students for the development of skill set in the 3D modelling tool (Fusion 360).
3. Activity provides space to students giving responsibility for their own learning to make them into independent thinkers.
4. Activity that makes the students to have critical thinking, developing an expert mind set in Geometric dimensioning and tolerances, problem-solving and teamwork.

PROBABILITY AND STATISTICS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – IV	
Subject Code : 22ME2401	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Apply statistical principles and probability concepts to solve complex problems in real-world scenarios involving uncertainty and randomness. 2. Evaluate and select appropriate probability distributions and statistical techniques to analyze and interpret data accurately in various applications. 3. Justify the use of estimation methods and hypothesis testing techniques for drawing meaningful inferences about population parameters. 4. Analyze and interpret sample test results for different statistical relationships, such as means, variances, correlation coefficients, regression coefficients, goodness of fit, and independence, to make informed decisions. 5. Identify sample tests using appropriate statistical procedures to investigate the significance of observed data and communicate findings effectively.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Probability	09 Hours
Definitions of Probability, Addition Theorem, Conditional Probability, Multiplication Theorem, Bayes' Theorem of Probability	
UNIT – II: Random Variables and their Properties and Probability Distributions	09 Hours
Discrete Random Variable, Continuous Random Variable, Joint Probability Distributions Their Properties, Probability Distributions: Discrete Distributions: Binomial, Poisson Distributions and their Properties; Continuous Distributions: Exponential, Normal, Distributions and their Properties.	

UNIT – III: Estimation and testing of hypothesis	06 Hours
Sample, Populations, Statistic, Parameter, Sampling Distribution, Standard Error, Un-Biasedness, Efficiency, Maximum Likelihood Estimator, Notion & Interval Estimation.	
UNIT – IV: Sample Tests-1	07 Hours
Large Sample Tests Based on Normal Distribution, Small Sample Tests: Testing Equality of Means, Testing Equality of Variances, Test of Correlation Coefficient	
UNIT – V: Sample Tests-2	08 Hours
Test for Regression Coefficient; Coefficient of Association, 2 – Test for Goodness of Fit, Test for Independence.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the principles of probability to solve complex problems in various real-world scenarios.	L2 & L3
2	Solve and compare different probability distributions, including discrete and continuous random variables, in order to make informed decisions and predictions.	L2 & L3
3	Apply statistical estimation techniques, such as maximum likelihood estimation and interval estimation, to draw meaningful inferences about population parameters from sample data.	L3
4	Examine hypothesis testing methods, including large and small sample tests, to assess the significance of observed data and draw valid conclusions.	L4
5	Analyze statistical relationships and perform sample tests to assess the Equality of means in different populations, Correlation coefficients between variables to determine the strength and direction of the relationship. Independence of variables using appropriate statistical tests to assess the absence of any relationship.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	2	2		2				1					
C02	3	2	2		2				1					
C03	3	2	2						1					
C04	3	2	2		2				1					
C05	3	2	2		2				1					

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. Probability & Statistics for Engineers and Scientists, Walpole, Myers, Myers, Ye.
Pearson Education.

REFERENCE BOOKS:

3. Probability, Statistics and Random Processes T. Veerarajan Tata McGraw – Hill
4. Probability & Statistics with Reliability, Queuing and Computer Applications, Kishor S. Trivedi, Prentice Hall of India ,1999

E-Resources:

1. <https://nptel.ac.in/courses/106104233>
2. <https://nptel.ac.in/courses/117103067>
3. <https://nptel.ac.in/courses/103106120>
4. <https://www.coursera.org/learn/probability-intro#syllabus>
5. <https://nptel.ac.in/courses/111104073>

Activity Based Learning (Suggested Activities in Class)

1. Tools like Python programming, R programming can be used which helps student to develop a skill to analyze the problem and providing solution.
2. Regular Chapter wise assignments/ Activity/Case studies can help students to have critical thinking, developing an expert mind set, problem-solving and teamwork.

Following are Activities Can carried out in place of Assignments using either R programming language or Python Programming or excel solver.

1. There are n people gathered in a room. What is the probability that at least 2 of them will have the same birthday? (Use excel solver, R Programming, Python Programming)
 - a. Use simulation to estimate this for various n., and Produce Simulation Graph.
 - b. Find the smallest value of n for which the probability of a match is greater than 0.5.
 - c. Explore how the number of trials in the simulation affects the variability of our estimates.
2. **Case Study 1: Customer Arrivals at a Coffee Shop**
 - a. Background: A coffee shop wants to analyze the number of customer arrivals during its morning rush hour (7:00 AM to 9:00 AM). The shop has been recording the number of customer arrivals every 15 minutes for the past month.
 - b. Data: The data consists of the number of customer arrivals recorded at the coffee shop during each 15-minute interval for the past month.
 - c. Here is a sample of the data:

Time Interval	Customer Arrivals
7:00 AM - 7:15 AM	6
7:15 AM - 7:30 AM	4
7:30 AM - 7:45 AM	9
7:45 AM - 8:00 AM	7
8:00 AM - 8:15 AM	5
8:15 AM - 8:30 AM	8
8:30 AM - 8:45 AM	10
8:45 AM - 9:00 AM	6

analyze the customer arrivals and determine the probability distribution that best fits the data. Specifically, explore both discrete and continuous probability distributions, including the binomial, Poisson, exponential, and normal distributions.

3. Case Study 2: Comparing the Performance of Two Groups

- a. Suppose you are a data analyst working for a company that manufactures a new energy drink. The marketing team conducted a promotional campaign in two different cities (City A and City B) to determine the effectiveness of the campaign in increasing sales. The sales data for a random sample of customers in each city was collected over a week. Your task is to compare the average sales between the two cities and test whether there is a significant difference in the variance of sales.

- b. Data: Let's assume the following sample data for the number of energy drinks sold in each city:

City A: [30, 28, 32, 29, 31, 33, 34, 28, 30, 32]

City B: [25, 24, 26, 23, 22, 27, 29, 30, 26, 24]

perform a two-sample t-test to test the equality of means and a test for equality of variances using Python's SciPy library.

4. case study 3: testing independence between two categorical variables.

- a. Data: Sample of 100 employees, and each employee is classified as either Male or Female. They were asked to rate their job satisfaction on a scale of 1 to 5, where 1 represents low satisfaction and 5 represents high satisfaction. The data is as follows:

Employee	Gender	Job Satisfaction
1	Male	4
2	Female	3
3	Male	2
4	Female	5
...	...	...
100	Female	4

- b. Test for independence between gender and job satisfaction, use the chi-squared test in R.

APPLIED THERMAL SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	: 22ME2402	Credits	: 03
Hours / Week	: 05 Hours	Total Hours	: 39+26 Hours
L-T-P-S	: 3-0-2-0		

Course Learning Objectives:

This Course will enable students to:

1. **Understand** Vapour power cycles and calculation of heat, work interactions and thermal efficiency
2. **Explain** the working of a single stage and multistage compressor and to calculate work done, volumetric-isothermal-polytrophic efficiencies
3. **Understand** refrigeration cycle and calculation of COP and to study different types of refrigerants and to appreciate the use of eco-friendly refrigerants
4. **Study** combustion thermodynamics of fuels
5. **Carry** out tests to investigate the performance of internal combustion engines
6. **Describe** and illustrate the idea of Backtracking and Branch and Bound algorithm design techniques to solve a given problem.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT - I	08 Hours
Gas Power Cycles Review of thermodynamics laws, Carnot, Otto, Diesel and Dual Cycles; simple Gas turbine cycle (Brayton cycle) and Modifications; Multistage compression with intercooling, Regeneration, reheat cycles practical gas turbine, cycles; Jet Propulsion cycles (Text Book-2: Chapter 13.1: 13.22),	
UNIT - II	08 Hours
Vapour Power Cycles and Combined cycle power plants Components of steam power plant, Carnot vapour power cycles, limitation of Carnot cycle, Simple Rankine cycle; Effect of pressure and Temperature on performance of Rankine Cycle, Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, feed water heaters. Reheat Rankine cycle, Supercritical Rankine cycle, combined gas and vapour cycle power plants. Numerical (Text Book-2: Chapter 12:12.1, 12.14)	
UNIT - III	06 Hours
Reciprocating Compressors Classification; work done in a single stage compressor; efficiency; p-v diagram for an actual compressor and diagram factor; multistage compressor; Multistage compressor with intercooler, Performance parameters for reciprocating compressors (Text Book-2: Chapter 17:17.1, 17.06)	
UNIT - IV	10 Hours
Refrigeration and Air conditioning Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Vapour absorption refrigeration system. Psychometric: Nomenclature, Definition, use of Psychometric chart, Introduction to air-conditioning, different types of air-conditioning systems (Text Book-2: Chapter 14:14.1, 14.12)	
UNIT - V	08 Hours
Combustion Thermodynamics Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions. (Text Book-2: Chapter 19:19.1, 19.10)	
Course Outcomes: At the end of the course the student will be able to: - Calculate work obtained, mean effective pressure and thermal efficiency for Otto, Diesel , Dual and Bryton cycles, Thermal efficiency of Basic, modified , reheat and regenerative Rankine cycles - Calculate the work done and efficiency for single stage and multistage compressor - Analyze different refrigeration and air-conditioning cycles - Analyze combustion thermodynamics of fuels	

	- Estimate the properties of fuels and lubricants like flash and fire point, viscosity and calorific value. - Predict I C engine performance parameters at different operating conditions and also to carry out heat balance
Sl. No	List of Laboratory/Practical Experiments activities to be conducted (if any) Total 26 Hrs
1	Determination of Flash point and Fire point of lubricating oil using Abel, Pensky and Marten's (closed) / Cleveland's (Open Cup) Apparatus.
2	Determination of Calorific value of solid, liquid and gaseous fuels.
3	Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
4	Valve Timing/port opening diagram of an I.C. engine (4 stroke/2 stroke).
5	Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal Efficiencies, Volumetric efficiency, Mechanical efficiency, SFC, FP, A-F Ratio, heat balance sheet
6	Determination of temperature distribution, fin efficiency in natural / forced Convection

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	2
C02	3	3	3	3	2								2	2
C03	3	3	3	3	2								2	2
C04	3	3	3	3	2								1	1
C05	3	3	2	2	2								1	1
C06	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

- Kadambi, T. R Seetaraman and K. B Subramanya Kumar, Applications of Thermodynamics, Wiley India Private Ltd, New Delhi, 2019.
- Nag P.K Basics and applied thermodynamics, Second edition, Tata McGrawHill, New Delhi, 2017.

REFERENCE BOOKS:

- Yunus A Cengel and Michael A Boles, Thermodynamics: An Engineering Approach, McGraw Hill Education.2017
- Michael J. Moran and Howard N. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd, 2006.

E-Resources:

- <https://nptel.ac.in/courses/112103307>
- <https://archive.nptel.ac.in/courses/112/106/112106314/>
- http://gateandupscexammaterials.yolasite.com/resources/standard_books/Applied%20Thermodynamics%20by%20Onkar%20Singh.0001.
- https://onlinecourses.nptel.ac.in/noc22_me113/preview

Activity Based Learning (Suggested Activities in Class)

7. students to conduct a thermodynamic analysis of a refrigerator using the principles of thermodynamics they have learned. This will help them understand how refrigerators work and how energy is transferred in a refrigeration cycle.
 8. students to conduct experiments on the thermodynamic properties of materials, such as thermal conductivity and specific heat. This activity will help students understand how the properties of materials affect their thermodynamic behaviour.
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KINEMATICS AND DYNAMICS OF MACHINES [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – IV	
Subject Code : 22ME2403	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Impart knowledge on the kinematics and dynamics of planar mechanisms 2. Analyze the bodies which is in motion using the basics of kinetics and kinematics 3. Determine the balancing of masses of rotating and reciprocating machine elements 4. Understand the principles of cams and followers 5. Distinguish the performance of different governors by characterize effort, power and sensitiveness 6. Understand the gyroscopic principle and verifying its effect by changing the torque.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I BASICS OF MECHANISMS	07 Hours
BASICS OF MECHANISMS Definitions Link or element, kinematic pairs, chain, Mechanism and Structure, Degrees of freedom, Grubler's criterion. (Text Book-1: Chapter 1: 1.1, 1.2, 1.4, 1.5, .6, 1.7, 1.8, 1.9, 1.10, 1.11) Inversions of various mechanism. Quick return motion Mechanisms. (Text Book-1: Chapter 1: 1.12, 1.13, 1.16, 1.17, 1.18) Straight line motion mechanisms. Intermittent Motion mechanisms. Toggle mechanism, Pantograph, Steering gears mechanism. Universal Hook's Joint. (Text Book-1: Chapter 6: 6.1, 6.2, 6.4, 6.5, 6.7, 6.8,6.9)	

UNIT – II KINEMATIC ANALYSIS		07 Hours
KINEMATIC ANALYSIS Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism. <i>(Text Book-1: Chapter 2 & 3: 2.1, 2.5, 2.6, 2.7, 2.8, 2.93.1, 3.2, 3.4)</i> Relative velocity and acceleration of particles in a common link and coincident Particles on separate links- Coriolis component of acceleration. <i>(Text Book-1: Chapter 2 & 3: 2.10, 3.5, 3.6)</i> Velocity Analysis by Instantaneous Center Method. Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism. <i>(Text Book-1: Chapter 2 & 3: 2.12, 2.13, 2.14, 3.8)</i>		
UNIT – III STATIC AND DYNAMIC FORCE ANALYSIS		08 Hours
STATIC AND DYNAMIC FORCE ANALYSIS Introduction, Static equilibrium. Equilibrium of two and three force members, members with two forces and torque, free body diagrams. Principle of virtual work, static force analysis of various mechanisms with and without friction. <i>(Text Book-1: Chapter 12 : 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, 12.8, 12.9)</i> Dynamic Force Analysis: D'Alembert's principle, inertia force and torque. Dynamic force analysis of four-bar and slider crank mechanism. <i>(Text Book-1: Chapter 13 : 13.1, 13.2, 13.3, 13.4, 13.5, 13.7, 13.10)</i>		
UNIT – IV BALANCING OF ROTATING AND RECIPROCATING MASSES		07 Hours
BALANCING OF ROTATING AND RECIPROCATING MASSES Static and dynamic balancing. Balancing of single and several rotating mass. <i>(Text Book-1: Chapter 14 : 14.1, 14.2, 14.3, 14.4)</i> Balancing of single cylinder engine: multi cylinder-inline engine (primary & secondary forces), V-type engine. Balancing of locomotives <i>(Text Book-1: Chapter 14 : 14.6, 14.7, 14.8, 14.9, 14.10, 14.11)</i>		
UNIT – V CAMS, GOVERNORS, AND GYROSCOPE		10 Hours
CAMS, GOVERNORS, AND GYROSCOPE Types of cams and followers. Development of cam profile for various types of followers and its different motion. <i>(Text Book-1: Chapter 7 : 7.1, 7.2, 7.3, 7.5, 7.8, 7.9)</i> Governors: Types of governors; governor characteristics, force analysis of centrifugal governors. <i>(Text Book-1: Chapter 16 : 16.1, 16.2, 16.3, 16.4, 6.5, 16.11, 16.12, 16.13, 16.14, 16.15, 16.16, 16.17)</i> Gyroscope: Vector representation of angular motion. Gyroscopic couple, effect of gyroscopic couple on ship, plane disc, aeroplane. <i>(Text Book-1: Chapter 17 : 17.1, 17.2, 17.3, 17.4, 17.5, 17.6, 17.7)</i>		

Course Outcomes:

At the end of the course the student will be able to:

- **Analyze** and **interpret** the behaviour of kinematic mechanisms to understand their motion characteristics
- **Apply** kinematic principles and concepts to analyze the motion characteristics of mechanical systems and mechanisms.
- **Evaluate** the equilibrium of rigid bodies subjected to static and dynamic forces using appropriate
- **Utilize** appropriate balancing procedures to determine the magnitude and location of balancing masses
- **Model** cam profiles to represent their shape & motion characteristics and **estimate** the power requirements for governors & gyroscope systems based on input-output specifications.

Table: Mapping Levels of COs to POs / PSOs															
COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	2								2	2	3
CO2	3	3	3	3	2								3	3	3
CO3	3	3	3	3	3								2	2	3
CO4	3	3	3	3	2								2	2	3
CO5	3	3	3	3	2								2	2	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Theory of Machines, Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2014.

Reference Books:

1. Theory of Machines & Mechanisms, J.J. Uicker, G.R. Pennock, J.E. Shigley. Oxford University Press, 4th Edition, 2010.
2. Theory of Machines, Thomas Bevan, CBS Publication 3rd Edition, 2005.
3. Theory of Mechanisms and Machines: Amitabha Ghosh and Ashok kumar Mallik, 3rd Edition Affiliated East-West Press.1976.

E-Books / Online Resources/VIRTUAL LABS:

1. <https://mm-nitk.vlabs.ac.in/>

MOOC:

1. <https://nptel.ac.in/courses/112105268>
2. <https://archive.nptel.ac.in/courses/112/104/112104114/#>

Activity Based Learning (Suggested Activities in Class)

1. Activity which makes students to apply the concepts learned in the course to the development of mechanism based on the real time applications will be discussed in class.
2. Activity that makes the students for the development of skill set in analysis of mechanisms.
3. Activity provides space to students giving responsibility for their own learning to make them into independent thinkers.
4. Activity that makes the students to have critical thinking, developing an expert mind set, problem-solving and teamwork.

MECHANICS OF SOLIDS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	: 22ME2404	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-S	: 3-0-0-0		

Course Learning Objectives:

This Course will enable students to:

1. **Explain** about the analysis of stresses and strains in straight, Stepped and tapered sections, Composite sections under axial, shear & thermal loading conditions.
2. **Describe** the evaluation of compound stresses and strains in a structural member using analytical & Mohr's circle method. And
3. **Determine** the circumferential and longitudinal stresses in thin and thick cylindrical pressure vessels.
4. **Describe** about the construction of shear force and bending moment diagrams for cantilever, simply supported and overhanging beams subjected to concentrated loads, uniformly distributed loads, moments and uniformly varying loads.
5. **Calculate** the shear stress due to torsion in tapered shaft, Shafts in series and Parallel, Thin Tubular and Thin-walled sections. And
6. **Explain** how to use Euler's Theory of Columns to calculate the buckling load of the columns with pinned ends, both ends are fixed, one end fixed & other is free and one end fixed & other is hinged.
7. **Describe** about computation of strain energy due to axial, shear, bending & torsional stresses.
8. **Clarify** how to use Theories of Failure to determine the factor of safety when it is subjected to combined stresses.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt the Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I Analysis of Stress and Strain	08 Hours
INTRODUCTION: Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them. Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change. (Text Book-1: Chapter 2: 2.3 to 2.11)	
UNIT – II Compound Stresses and Cylinders	08 Hours
Compound Stresses: Principal stresses and maximum shear stress, Planes of Principal stress and Maximum Shear stress, Normal stress on the planes of maximum shear stress, Mohr's circle for plane stress conditions. (Text Book-3: Chapter 3: 3.4, 3.5) Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, thin spherical Shell, thin cylinder with spherical ends. Thick cylinders: Lamé's theory. (Text Book-2: Chapter 17: 17.4, 17.5, 17.10)	
UNIT – III Shear Forces and Bending Moments	06 Hours
Shear Forces and Bending Moments: Type of beams, Loads and reactions, Relationship between loads, Shear force and bending moments of cantilever, simply supported and overhanging beams subjected to concentrated loads and uniformly distributed constant / varying loads. (Text Book-2: Chapter 6: 6.3 to 6.18) Stress in Beams: Bending Theory, Bending and shear stress distribution in rectangular, I and T section beams. (Text Book-2: Chapter 7: 7.2 to 7.4)	
UNIT – IV Torsion and Columns	09 Hours
Torsion: Circular shafts, Power Transmission, Torsion of tapered shaft, Shafts in series and Parallel, Thin Tubular and Thin-walled sections. (Text Book-1: Chapter 3: 3.3, 3.13). Columns: Euler's theory, Equivalent Length, Limitations of Euler's Formula, Rankine's Formula (Text Book-2: Chapter 19: 19.3 to 19.10).	
UNIT – V Strain Energy and Theories of Failure	08 Hours
Strain Energy: Strain energy due to axial, shear, bending, torsion and impact load, Castigliano's theorem and their applications. (Text Book-1: Chapter 11: 11.2 to 11.12) Theories of Failure: Introduction, maximum principal stress theory (Rankine's theory), Maximum shearing stress theory (Guest's and Tresca's theory), maximum principal strain theory (St. Venant's theory), Maximum Strain energy theory (Haigh's Theory) and Maximum Shear Strain Energy Theory (Mises' and Henkeys's Theory) (Text Book-2: Chapter 04: 4.1 to 4.4)	
Course Outcomes: At the end of the course the student will be able to:	

- **Calculate** stress and strain for different geometries under different loading conditions
- **Solve** for principal stresses, maximum shearing stress acting on a structural member using analytical and Mohr's circle methods
- **Calculate** the stresses and strains associated with thin and thick cylindrical pressure vessels under axial and circumferential loads
- **Construct** shear force and bending moment diagrams for statically determinate beams
- **Calculate** the shear stress for bodies subjected to torsion and bending stresses for columns
- **Select** appropriate failure theory to calculate the safe dimensions of components and structures

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
C01	3	3	3	3	3								2	2	3
C02	3	3	3	3	2								3	3	3
C03	3	3	3	3	2								2	2	3
C04	3	3	3	3	3								2	2	3
C05	3	3	3	3	2								2	2	3
C06	3	3	3	3	2								1	1	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. F. P. Beer and E. R. Johnston (2020), Mechanics of Materials, 8th Edition, McGraw Hill publications.
2. S. S. Bhavikatti (2017), Mechanics of Solids, New Age International Publications.

REFERENCE BOOKS:

1. Stephen Timoshenko (2002), Strength of Materials, 3rd Edition, CBS Publisher.
2. Strength Of Materials, 16/e Paperback – 1 January 2011
3. Ramamrutham S, Dhanpat Rai Publishing Company (p) Ltd (1 January 2011)

E-Resources:

17. <https://archive.nptel.ac.in/courses/105/105/105105108/>
18. https://onlinecourses.nptel.ac.in/noc22_ce46/preview
19. <https://www.youtube.com/watch?v=LIZ-PQbGZkA>

Activity Based Learning (Suggested Activities in Class)

9. Real world problem solving and puzzles using group discussion.
10. Demonstration of solution to a problem through experiential learning.
11. Demonstrations using real objects, taking students on an educational tour.

HEAT TRANSFER	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – IV	
Subject Code : 22ME2405	Credits : 04
Hours / Week : 04 Hours	Total Hours : 39+26 Hours
L-T-P-S : 3-0-2-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Understand the basic phenomenon of heat transfer and its importance in engineering applications. 2. Enable the students to understand the different modes of heat transfer like conduction, convection and radiation. 3. Understand the mechanism of heat transfer under steady and transient conditions 4. Illustrate the applications of convective heat transfer including heat exchangers, boiling & condensation 5. Understand the different laws of radiation and applying for solving engineering problems	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	05 Hours
Modes of heat transfer: Basic laws governing conduction, Thermal conductivity. Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, discussion on 3-D conduction in cylindrical and spherical coordinate system. One dimensional conduction equations for plane, cylinder and spheres. Overall heat transfer coefficient, Thermal conductive resistance and numerical problems. Derivation for	

heat flow and temperature distribution in a plane for variable thermal conductivity case, critical thickness of insulation and numerical problems. (Text Book2: Chapter 1: 1.1, 1.6)	
UNIT - II	05 Hours
Heat transfer through rectangular fin , infinitely long fin, short fin with insulated tip and without insulated tips. FIN efficiency and effectiveness. Numerical problems. (Text Book 1: Chapter 3: 3.1, 3.8) Transient Conduction: Lumped parameter analysis, use of transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, numerical problems (Text Book1: Chapter 4: 4.1, 4.7)	
UNIT - III	05 Hours
Natural Convection: Introduction, laminar flow, momentum and energy equations for vertical flat plate, physical significance of Grashoff number, use of correlations for free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, numerical problems. (Text Book1: Chapter 6: 6.1, 6.7) Forced Convection: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems. (Text Book1: Chapter 9: 9.1, 9.7)	
UNIT - IV	06 Hours
Fundamental concepts of radiation , different laws governing radiation heat transfer, Stefan Boltzman law, Kirchoff's law, Planck's law, Wein's displacement law, Intensity of radiation and Lambert's cosine law, Radiation shape factor, Heat exchange by radiation between two black and diffuse grey surfaces, radiation shields, numerical problems. (Text Book1: Chapter 12: 12.1, 12.11)	
UNIT - V	05 Hours
Heat exchangers: Classification and applications, overall heat transfer coefficient, heat exchanger analysis-Logarithmic mean temperature difference for parallel and counter flow heat exchanger, effectiveness-number of transfer units, method for parallel and counter flow heat exchanger, introduction to cross flow heat exchanger, Logarithmic mean temperature difference correction factor. Numerical problems. (Text Book1: Chapter 11: 11.1, 11.08) Condensation and Boiling: Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation. (no numerical problems). (Text Book1: Chapter 10: 10.1, 10.11)	
Course Outcomes: At the end of the course the student will be able to:	
• Compute temperature distribution and heat flow in steady-state and unsteady-state 1-D heat conduction • Calculate forced and free convective heat transfer coefficient and rate of heat transfer • Analyze performance characteristics of heat exchangers • Calculate radiation heat transfer between objects with simple geometries • Demonstrate conduction, convection, and radiation heat transfer phenomena through experiments	

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	2
C02	3	3	3	3	2								2	2
C03	3	3	3	3	2								2	2
C04	3	3	3	3	2								1	1
C05	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Sl. No	List of Laboratory/Practical Experiments activities to be conducted (if any)	Total 26 Hrs
1	Determination of thermal conductivity of metal rod.	
2	Determination of thermal conductivity of composite wall.	
3	Experiment on transient conduction heat transfer	
4	Determination of heat transfer coefficient in natural convection.	
5	Determination of heat transfer coefficient in forced convection.	
6	Determination of temperature distribution, fin efficiency in natural / forced Convection	
7	Determination of emissivity of a test surface.	
8	Determination of the emissive power of black body using Stefan's Boltzmann's constant	
9	Determination of effectiveness and logarithmic mean temperature difference in parallel flow and counter flow heat exchanger	

TEXT BOOKS:

1. Incropera, F.P. and DeWitt, D.P "Fundamentals of Heat and Mass transfer, John Wiley, 2011.
2. . J P Holaman Heat Transfer, Tata McGraw-Hill, 2009.

REFERENCE BOOKS:

1. P K Nag Heat and Mass Transfer, Tata McGraw-Hill, 2011.
2. Ozisik, Heat Transfer-A Basic Approach, 2002.

E-Resources:

1. <https://archive.nptel.ac.in/courses/103/105/103105140/>
2. <http://ecoursesonline.iasri.res.in/course/view.php?id=625>
3. <http://ecoursesonline.iasri.res.in/course/view.php?id=61>
4. <http://krunalkhiraiya.weebly.com/e-course-on-heat-transfer.html>

Activity Based Learning (Suggested Activities in Class)

1. Conduct a thermal conductivity experiment: Provide students with materials such as different types of metals
2. Investigate the effects of insulation: Provide students with materials such as Styrofoam, cotton, and wool, and have them investigate the effects of insulation on heat transfer by measuring the rate of heat loss from a hot object that is wrapped in each material

MACHINE LEARNING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – IV	
Subject Code : 22ME2406	Credits : 02
Hours / Week : 04 Hours	Total Hours : 13+26 Hours
L-T-P-S : 1-0-2-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Realize Machine Learning techniques in supervised and unsupervised learning. 2. Comprehend the ideas of ML and problem-solving techniques. 3. Use of Python Programming for different applications 4. Demonstrate the representation of knowledge and reasoning 5. Recognize the importance of ML in Mechanical Engineering	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours
Introduction to Python, Basics: Basic types, variables, Decision making and Loops, Strings, Data Structures: Lists, Tuples, Sets, and Dictionaries Regular Expression Operations, Modules. Object oriented programming in python: Classes, Constructors, and Object Methods. (Text Book-1: Chapter 5: 5.1 to 5.3, Chapter 6: 6.3 to 6.4, Chapter 7: 7.2 to 7.3)	
UNIT – II	
NumPy - Overview, NumPy Array creation and basic operations, NumPy Universal functions, Selecting and retrieving Data, Data Slicing. Pandas - Overview, Object Creation: Series Object, Data Frame Object, View Data, selecting data by Label and Position, Data Slicing, Setting Data, applying functions to data, Analysing Data for missing values.	

Matplotlib - Overview, creating basic chart: Line Chart, Bar Charts and Pie Charts, Plotting from Pandas object, Saving a plot. **(Text Book-1: Chapter 8: 8.4).**

UNIT - III		06 Hours
INTRODUCTION: Introduction to Supervised learning, Linear Regression Logistic Regression, Naive Bayes, Decision Tree, KNN, Random Forest, Support VectorMachine Introduction to Unsupervised learning, PCA, clustering approaches: K-means, Hierarchical clustering Natural Language Processing: Language models, n-grams, Vector space models, Bag of words. <i>(Text Book-1: Chapter 1: 1.1 to 1.2)</i>		
UNIT - IV		08 Hours
Neural Network basics: History behind neural networks, Relationship between biological neuron and artificial neuron, Perceptron and working mechanism, Architecture of artificial neuralnetwork, Types of activation functions. <i>(Text Book-1: Chapter 3: 3.1, 3.2)</i>		
UNIT - V		08 Hours
Machine learning application using python for mechanical engineering datasets: mechanical vibrations - heat transfer - fluid mechanics – manufacturing process. Smart Manufacturing, Smart Transportation and Autonomous Vehicles. Robotics, Quality control. <i>(Text Book-1: Chapter 12: 12.2, 12.3)</i>		
<u>Course Outcomes:</u> At the end of the course the student will be able to: • Apply Python Programming for solving engineering problems • Demonstrate the representation of knowledge and reasoning • Develop the ideas of AI and problem-solving techniques • Demonstrate Machine Learning techniques in supervised and unsupervised learning • Employ data science, AI & ML techniques in solving in Mechanical Engineering		

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	1
C02	3	3	3	3	3								1	1
C03	3	3	3	3	3								2	2
C04	3	3	3	3	3								2	2
C05	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. Nagy Z. Artificial Intelligence and Machine Learning Fundamentals: Develop real-world applications powered by the latest AI advances. Packt Publishing Ltd; 2018.
2. Sebastian Raschka and Vahid Mir Jalili, Python Machine Learning, Second Edition: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow Paperback – September 20, 2017

REFERENCE BOOKS:

1. David L. Poole, Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
2. Nils J. Nilsson, the Quest for Artificial Intelligence, Cambridge University Press, 2009.

E-Resources:

1. <https://nptel.ac.in/courses/106/101/106101060/>
2. <http://cse01-iiith.vlabs.ac.in/>
3. <http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms>
4. <https://www.coursera.org/specializations/algorithms> .

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion. E.g., Fake coin identification, Cabbage puzzle, Konigsberg bridge puzzle etc.,
 2. Demonstration of solution to a problem through programming.
-

MICROPROCESSORS AND MICROCONTROLLERS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand Fundamental Concepts: Acquire a thorough understanding of microprocessor and microcontroller architectures and operations. 2. Develop Programming Skills: Learn to program and debug microprocessors and microcontrollers using assembly and high-level languages. 3. Design and Integration Skills: Master the integration of microcontrollers with mechanical components and systems. 4. Apply Real-World Technologies: Explore real-world applications, focusing on microcontroller roles in mechanical systems and IoT. 5. Enhance Problem-Solving Abilities: Enhance analytical and problem-solving skills through practical case studies and design challenges.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction to Microprocessors and Microcontrollers	09 Hours
Overview of Microprocessors and Microcontrollers: Differences and applications. History and Evolution: Key developments in microprocessor technology. Basic Architecture: CPU, memory, input/output, buses. Types of Microcontrollers: Comparison of 8-bit, 16-bit, and 32-bit microcontrollers.	
UNIT – II: Microprocessor Architecture and Programming	09 Hours
CPU Architecture: Registers, ALU, CU. Instruction Set: Types of instructions (data movement, arithmetic, control). Assembly Language Basics: Syntax, operations, and simple programming. Programming Model: Flags, stacks, interrupts, subroutine calls.	

UNIT – III: Microcontroller Hardware and Peripherals	06 Hours
Microcontroller Components: Clock system, timers, counters, watchdog timer. Input/Output Devices: GPIOs, ADC, DAC, PWM. Communication Protocols: SPI, I2C, UART, CAN. Interfacing Techniques: Sensors and actuators relevant to mechanical systems.	
UNIT – IV: System Design and Integration	07 Hours
Design Methodologies: From specifications to prototype. Embedded System Design: Integrating microcontrollers with mechanical components. Power Management: Considerations for energy-efficient design. Case Studies: Analysis of real-world mechanical applications using microcontrollers.	
UNIT – V: Advanced Topics and Applications	08 Hours
Real-Time Operating Systems (RTOS): Concepts and applicability. Internet of Things (IoT) and Connectivity: Role of microcontrollers in IoT for mechanical applications. Fault Tolerance and Safety: Ensuring reliability and safety in mechanical systems. Emerging Technologies: Overview of advancements like AI and ML integration with microcontrollers.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply microcontroller architecture knowledge to design and develop task-specific embedded systems in mechanical contexts.	L3
2	Analyze and optimize embedded system designs for efficiency and effectiveness in mechanical engineering applications.	L3
3	Evaluate and select optimal communication protocols for integrating microcontrollers with mechanical systems.	L4
4	Implement necessary fault tolerance and safety features in microcontroller-based mechanical systems.	L4
5	Integrate emerging technologies like IoT and AI to enhance the capabilities of microcontroller-driven mechanical systems.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	2	1	1	2	2	2	1	3	2
CO2	2	3	2	-	-	2	1	1	1	2	2	1	2	3
CO3	2	2	3	-	-	2	1	1	2	2	2	1	3	2
CO4	3	2	3	-	-	2	1	1	2	2	2	1	2	2
CO5	2	2	3	-	-	2	1	1	2	2	2	1	3	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbook:

1. Mazidi, M. A. (2007). The 8051 Microcontroller And Embedded Systems Using Assembly And C, 2/E. Pearson Education India.
2. Brey, B. B. (2009). The Intel microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium Pro processor, Pentium II, Pentium III, Pentium 4, and Core2 with 64-bit extensions: architecture, programming, and interfacing.

Reference books:

1. Simon, D. E. (1999). An embedded software primer (Vol. 1). Addison-Wesley Professional.
2. Catsoulis, J. (2005). Designing Embedded Hardware: Create New Computers and Devices. " O'Reilly Media, Inc."

CLOUD COMPUTING & DATA PROCESSING [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Gain a foundational understanding of data analytics, artificial intelligence, and cloud computing, focusing on their impact on mechanical engineering. 2. Acquire skills in developing and implementing AI models for mechanical engineering applications using tools like TensorFlow and PyTorch. 3. Learn to manage, process, and analyze large datasets with advanced data management tools and techniques, ensuring data integrity and security. 4. Understand and apply cloud computing solutions to enhance AI-driven data processing and analytics in mechanical engineering projects. 5. Utilize knowledge of AI, data analytics, and cloud technologies to innovate and improve mechanical systems design, maintenance, and manufacturing processes.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I: Introduction to Data Analytics and AI	09 Hours
Basics of Data Analytics: Key concepts, importance, and roles in mechanical engineering. Introduction to Artificial Intelligence: Understanding AI, its components like machine learning, deep learning, and their relevance to engineering. AI in Engineering: Examples of AI applications in mechanical systems, design, and manufacturing.	
UNIT – II: AI Techniques for Engineering	09 Hours
Machine Learning Models: Supervised and unsupervised learning techniques applied to mechanical engineering data. Deep Learning Fundamentals: Introduction to neural networks,	

CNNs, and RNNs tailored for complex engineering problems. AI Tools and Libraries: Practical sessions on using AI libraries such as TensorFlow, PyTorch in engineering applications.

UNIT – III: Data Management and Advanced Analytics

06 Hours

Big Data Technologies: Using platforms like Hadoop and Spark for handling large-scale engineering data. Advanced Analytics Methods: Integrating predictive and prescriptive analytics to optimize mechanical operations and designs. Data Privacy and Security: Best practices for handling sensitive engineering data, focusing on regulatory and ethical considerations.

UNIT – IV: Cloud Computing and AI Integration

07 Hours

Cloud Service Models for AI: How IaaS, PaaS, SaaS can be leveraged for AI-driven engineering tasks. Cloud-Based AI Tools: Utilization of cloud platforms for deploying and managing AI models, including AWS SageMaker, Google AI Platform. IoT and Cloud AI: Integrating IoT devices with cloud-based AI for smarter data analytics in real-time applications.

UNIT – V: Real-World Applications and Case Studies

08 Hours

Predictive Maintenance using AI: Employing machine learning models to predict equipment failures and schedule maintenance. AI in Smart Manufacturing: Case studies on the use of AI and IoT in automating and optimizing manufacturing processes. Innovations in AI for Mechanical Engineering: Exploration of cutting-edge AI applications like autonomous robotic systems, additive manufacturing, and dynamic system simulations.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply analytical techniques to solve complex problems in mechanical engineering using data analytics and AI tools.	L3
2	Design and implement AI models using current technologies to optimize mechanical system performance.	L4
3	Evaluate and select appropriate cloud-based solutions for data-intensive mechanical engineering applications.	L3
4	Integrate and manage IoT devices with cloud computing and AI to enhance real-time data processing and decision-making.	L3
5	Demonstrate proficiency in using advanced data analytics to predict maintenance needs and improve manufacturing processes.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	2	-	2	1	1	2	2	1	1	3	2
C02	3	3	3	2	-	1	1	1	2	2	1	1	3	2
C03	2	2	2	1	-	1	1	1	2	2	1	1	2	3
C04	2	2	3	2	-	1	1	1	2	2	1	1	3	3
C05	3	3	3	2	-	2	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Mitchell, M. (2019). Artificial intelligence: A guide for thinking humans. Penguin UK.
2. Dean, J. (2014). Big data, data mining, and machine learning: value creation for business leaders and practitioners. John Wiley & Sons.

References:

1. Shukla, N., & Fricklas, K. (2018). Machine learning with TensorFlow. Greenwich: Manning.
2. Erl, T., Puttini, R., & Mahmood, Z. (2013). Cloud computing: concepts, technology & architecture. Pearson Education.

DESIGN OF MACHINE ELEMENTS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	04
Hours / Week	:	04 Hours	Total Hours	:	26+26 Hours
L-T-P-S	:	2-1-2-0			

Course Learning Objectives:

This course will enable students to:

1. Understand the stresses in machine members due to various types of loads and failure of components according to theories of failures.
2. Analyze the components under variable loading for infinite and finite life.
3. Design of machine elements under torsion, bending, axial loads and a combination of these.
4. Design of permanent and temporary joints and fasteners for a given load to be transmitted. Design of various screws, keys, coupling and shafts.
5. To understand use of different types of springs and determine safe design of spring under static and fluctuating loading conditions.
6. To understand the standard nomenclature, forces, failures, application, design procedure of Spur and Helical gears (As per AGMA)
7. To understand the standard nomenclature, forces, failures, application, design procedure of Bevel and Worm gears (As per AGMA) and to determine standard geometry under given loading condition
8. To understand the design procedure, failures and application of Ball Bearings and Sliding contact bearing
9. Design the clutches and brakes required for power transmission.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analyzing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

- Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding. Practical experimentation of curved beam, journal bearing, shaft and gears	
UNIT - I	08 Hours
Normal, shear, biaxial and triaxial stresses, factor of safety, stress concentration factor in tension, bending and torsion, theories of failures, static strength: static loads, impact strength: introduction, impact stresses due to axial, bending and torsional loads, Failure of brittle and ductile materials (text book-1: chapter 3: 3.10 to 3.13, chapter 5: 5.1 to 5.10) Introduction, S-N diagram, low cycle fatigue, high cycle fatigue, endurance limit, modifying factors: size effect, surface effect, stress concentration effects, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage. (Text Book-1: Chapter 6: 6.1 to 6.8)	
UNIT - II	08 Hours
Threaded fasteners: stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints. (Text Book-1: Chapter 8: 8.1 to 8.12) Riveted and welded joints: types, rivet materials, failures of Riveted joints, joint efficiency, boiler joints, riveted brackets. Welded joints: types, strength of butt and fillet welds, eccentrically loaded welded joints. (Text Book-1: Chapter 9: 9.1 to 9.8)	
UNIT - III	08 Hours
Joints: Types of keys, design of socket-spigot cotter joint, design of knuckle joint. Couplings: Types of couplings, design of flange and flexible couplings and muff coupling (Text Book-1: Chapter 8: 8.1 to 8.12) Shafts: torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under fluctuating loads and combined loads. Curved beams: stresses in curved beams of standard cross sections used in crane hook (Text Book-1: Chapter 7: 7.1 to 7.8)	
UNIT - IV	10 Hours
Springs: types, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, springs under fluctuating loads. Leaf springs: stresses in leaf springs. Equalized stresses, energy stored in springs, torsion. (Text Book-1: Chapter 10: 10.1 to 10.13) Gears: Spur gears, Helical gears, Bevel Gears and Worm Gears: Definitions, stresses in gear tooth: Lewis's equation and form factor, design based on strength, dynamic and wear loads, formative number of teeth, formative number of teeth, efficiency of worm gear drives (Text Book-1: Chapter 13: 13.1 to 13.11)	
UNIT - V	08 Hours
Bearings: lubricants and their properties, mechanisms of lubrication bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, heat dissipated, bearing materials, examples of journal bearing and thrust bearing design. (Text Book-1: Chapter 12: 12.1 to 12.15) Clutches & Brakes: Design of clutches: Single plate, multi plate and cone clutches. Design of Brakes: Block and band brakes: Self-locking of brakes: Heat generation in brakes. (Text Book-1: Chapter 16: 16.1 to 16.10)	
LIST OF LABORATORY/PRACTICAL EXPERIMENTS ACTIVITIES TO BE CONDUCTED: 28 HRS	
Determination of principal stresses and strains in a member subjected to combined Loading using strain rosettes and verification using FEA tool.	

2. Determination of critical speed of a rotating shaft and verification using FEA tool.
3. Determination of stresses in curved beam using strain gauge and verification using FEA tool.
4. Design of shafts subjected to direct and combined loading for given loads and conditions and comparing design by using CAD/CAE software.
5. Determination of pressure distribution in journal bearing
6. Modelling and stress analysis of spur and helical gear tooth by using CAD/CAE software
7. Modelling and stress analysis of helical and leaf springs using CAD/CAE software
8. Modelling and stress analysis of brake by using CAD/CAE software
9. Modelling and stress analysis of single plate and multi-plate clutches by using CAD/CAE software

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Classify various stresses acting on a machine element and compute the dimensions of component based on the concepts of failure theories	L3												
2	Quantify factor of safety, failure modes for mechanical components subjected to direct and bending and combined loading	L4												
3	Analyze the design of threaded fasteners, riveted joints and welding joints and calculate the strength of butt and fillet welds	L3												
4	Choose the appropriate keys, coupling, shafts and joints in the design of machine components. Classify different kinds of springs, gears, bearings, clutches and brakes and Compute tooth strength for spur, helical, bevel and worm gears	L3												
5	Interpret the pressure distribution in a journal bearing and select suitable clutch plate and brake shoe for a given application	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	2	3	-	3	2	1	1	2	2	2	1	3	2
C02	3	3	2	-	3	2	1	1	2	2	2	1	3	2
C03	3	2	3	-	3	2	1	1	2	2	2	1	3	2
C04	3	3	3	-	3	2	1	1	2	2	2	1	3	3
C05	2	3	2	-	3	1	1	1	2	2	2	1	3	2
C06	3	2	3	-	3	2	1	1	2	2	2	1	3	2

TEXT BOOKS:

1. Shigley, J. E., Mitchell, L. D., & Saunders, H. (1985). Mechanical engineering design.
2. Bhandari, V. B. (2010). Design of machine elements. Tata McGraw-Hill Education.

REFERENCE BOOKS:

1. Norton, R. L. (2010). Machine design. London, UK: Prentice Hall.
2. M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayram and C. V. Venkatesh (2019) Design of Machine Elements Pearson Education, Eighth edition.

E-Resources:

1. <https://nptel.ac.in/courses/112/105/112105124/>
2. <https://nptel.ac.in/courses/112/106/112106137/>

INTRODUCTION TO AUTOMATION AND ROBOTICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	04 Hours	Total Hours	:	26+26 Hours
L-T-P-S	:	2-0-2-0			

Course Learning Objectives:

This Course will enable students to:

1. Gain a comprehensive understanding of the fundamental concepts, history, and applications of robotics and automation in various industries.
2. Acquire knowledge and skills in the mechanical design of robotic systems, including kinematics, dynamics, and the selection of actuators and end-effectors.
3. Learn to program and interface robots using popular robotics programming languages and software, such as Python and ROS.
4. Understand the role and function of programmable logic controllers (PLCs) and how they integrate with robotic systems for enhanced automation solutions.
5. Study advanced applications and emerging trends in robotics, such as collaborative and mobile robotics, and assess their future impact on mechanical engineering.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I Introduction to Automation and Robotics		08 Hours
Overview of automation and robotics in industry; history and evolution of robotic systems; types of robots and their applications.		
UNIT – II Mechanical Design of Robotic Systems		08 Hours
Design principles of robotic systems; kinematics and dynamics of robots; end-effectors and actuators.		
UNIT – III Robotics Programming and Interfaces		06 Hours
Introduction to programming languages for robots (e.g., Python, ROS); interfacing with sensors and actuators.		
UNIT – IV Automation Technologies		10 Hours
Overview of automation technologies; PLCs and their role in automation; integration of robotic systems with manufacturing processes.		
UNIT – V Advanced Applications and Emerging Trends		08 Hours
Advanced robotic applications (collaborative robots, mobile robots); emerging trends in robotics and future implications for mechanical engineering.		
Sl. No	List of Laboratory/Practical Experiments activities to be conducted (if any)	
	Total 26 Hrs	
1	Basic safety training; introduction to robotic simulation software; simple tasks using robotic arms in simulation.	
2	Design and simulation of a robotic arm; calculation of degrees of freedom and range of motion; hands-on assembly of small robotic kits.	
3	Programming a robotic arm to perform specific tasks; sensor integration and basic task automation.	
4	PLC programming basics; creating control logic for automated sequences; interfacing PLCs with robotic arms.	
5	Experimentation with collaborative robots; introduction to mobile robotics and navigation algorithms; project presentations on innovative robotic solutions.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply fundamental robotics principles to design, analyze, and improve automation systems in mechanical engineering contexts.	L3
2	Demonstrate proficiency in programming and interfacing robotic systems for task-specific applications using industry-standard software.	L4
3	Integrate sensors, actuators, and controllers to develop comprehensive robotic systems that meet engineering specifications.	L3
4	Implement PLC programming and control logic to automate processes within robotic systems efficiently.	L3
5	Evaluate and adopt emerging robotic technologies, such as collaborative and mobile robots, for innovative mechanical engineering solutions.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	3	2	1	1	2	2	2	1	3	2
C02	3	3	2	-	3	1	1	1	2	2	1	1	3	3
C03	3	2	3	-	3	2	1	1	2	2	2	1	3	3
C04	3	3	3	-	3	1	1	1	2	2	1	1	3	2
C05	3	2	3	-	3	2	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. John J. Craig. (2017) Introduction to Robotics: Mechanics and Control by Pearson, 4th Edition,.
2. Corke, P. (2021). Robotics and control: fundamental algorithms in MATLAB® (Vol. 141). springer Nature.

Reference Books:

1. Mikell P. Groover (2014) "Automation, Production Systems, and Computer-Integrated Manufacturing" by, Prentice Hall, 4th Edition.
2. Corke, P. (2021). Robotics and control: fundamental algorithms in MATLAB® (Vol. 141). springer Nature.

THERMAL MANAGEMENT OF ELECTRONIC DEVICES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	04 Hours	Total Hours	:	26+26 Hours
L-T-P-S	:	2-0-2-0			

Course Learning Objectives:

This course will enable students to:

1. Appreciate the importance of thermal management for the performance and reliability of electronic devices
2. Identify how temperature impacts failure modes and component lifespan in electronic systems.
3. Utilize conduction, convection, and radiation principles in designing thermal management solutions
4. Evaluate and select appropriate cooling methods based on performance requirements and cost-effectiveness.
5. Apply simulations to optimize cooling strategies, predict temperature distributions, and evaluate thermal management effectiveness

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I	05 Hours
INTRODUCTION TO THERMAL MANAGEMENT: Understanding the critical role of thermal management in electronics, its impact on performance, reliability, and overall system lifespan. Overview of economic and operational consequences of thermal issues. TEMPERATURE EFFECTS ON FAILURE MODES: Exploration of how temperature affects failure mechanisms like thermal stress, fatigue, electromigration, and material expansion in electronic components.	
UNIT - II	05 Hours
CONDUCTION COOLING AND HEAT SINKS Study of materials and thermal interface materials (TIMs) used to enhance heat conduction in electronic systems HEAT SINK DESIGN: Core principles of heat sink design, including material choice, geometry, and surface treatments. examination of advanced configurations like pin-fin and vapor chamber heat sinks. CONVECTION COOLING: Overview of natural and forced convection cooling methods, focusing on fan selection, placement, and optimization for effective airflow management.	
UNIT - III	06 Hours
LIQUID COOLING TECHNIQUES Introduction to liquid immersion cooling, its principles, and the selection of appropriate dielectric fluids for high-performance applications, Flow-Through Cooling for Circuit Card Assemblies (CCAs) COLD WALL COOLING AND COLD PLATES: Exploration of cold wall cooling and cold plate designs, their applications, and integration into electronic systems for enhanced heat dissipation.	
UNIT - IV	05 Hours
ADVANCED AND EMERGING COOLING TECHNOLOGIES Principles and applications of jet impingement and synthetic jet cooling, focusing on their use for localized, high-efficiency cooling. Thermoelectric (Solid-State) Coolers COOLING USING PHASE CHANGE MATERIALS (PCM): Use of phase change materials in thermal management, including selection criteria and integration techniques.	
UNIT - V	05 Hours
MICRO/MINI CHANNEL COOLING: Applications of micro/mini channel cooling technologies in high-density and high-power electronics. HEAT PIPES: Study of heat pipe principles, working fluids, and their integration into thermal management systems for efficient heat transfer.	
LIST OF LABORATORY/PRACTICAL EXPERIMENTS ACTIVITIES TO BE CONDUCTED (IF ANY)	
TOTAL 26 HRS	
1. Simulate heat conduction through different materials and geometries using MATLAB, Study the effect of material properties (thermal conductivity) and boundary conditions on temperature distribution 2. CFD Analysis of Forced Convection Cooling: Analyze fluid flow and heat transfer in electronic cooling applications using CFD software (e.g., ANSYS Fluent) 3. Liquid Cooling System Simulation using Matlab and CFD: Develop a thermal model of a liquid cooling loop incorporating components like pumps, heat exchangers, and flow control valves using Matlab.	

4. Heat Pipe Simulation and Analysis: Simulate heat transfer in a heat pipe and analyze its effectiveness in thermal management.

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Apply the fundamental concepts of thermal management to assess their impact on the performance and reliability of electronic devices	L3												
2	Design and Evaluate heat sinks with optimal material choice, geometry, and surface treatments, including advanced configurations like pin-fin and vapor chamber heat sinks	L3												
3	Evaluate and Optimize different cooling methods, including heat sinks, liquid cooling, and advanced technologies like thermoelectric coolers and heat pipes, to enhance thermal performance	L4												
4	Analyze micro/mini channel cooling technologies to manage heat dissipation in high-density and high-power electronic applications	L3												
5	Simulate and Predict the thermal behavior of electronic systems using Matlab and CFD tools to develop and refine cooling strategies	L4												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	-	3	1	1	1	2	2	1	1	3	2
CO2	3	2	3	-	3	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	3	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	3	1	1	1	2	2	1	1	3	2
CO5	3	2	3	-	3	1	1	1	2	2	1	1	3	3
CO6	3	3	2	-	3	1	1	1	2	2	1	1	3	2
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

TEXT BOOKS:

- Frank P. Incropera and David P. DeWitt (2006) "Fundamentals of Heat and Mass Transfer", 6th Edition, John Wiley & Sons, Inc.
- D. Steinberg (1991). Thermal Management of Electronic Systems" John Wiley & Sons.

REFERENCE BOOKS:

- Andreas C. Papadakis (2015) "Thermal Design and Thermal Behaviour of Radio Frequency Devices" - CRC Press.

E-Resources:

- <https://nptel.ac.in/courses/113107078>
- <https://nptel.ac.in/courses/103105219>
- <https://nptel.ac.in/courses/112107221>
- <https://www.coursera.org/learn/crystal-structures-and-properties-of-metals?>

Skill Enhancement Course-III

Skill Enhancement Course-III CAE LAB-I (CATIA) [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 13+26 Hours
L–T–P–S	: 1–0–2–0		
Course Learning Objectives: This Course will enable students to: 1. Develop proficiency in using CATIA software for creating and editing 2D sketches and 3D models. 2. Equip students with the skills to design and modify complex parts and assemblies using CATIA's part and assembly workbenches. 3. Enhance students' ability to create and manage detailed surface models and perform advanced surface operations. 4. Prepare students to generate professional engineering drawings and documentation, including standard views, dimensions, and annotations, using CATIA's drafting tools.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

UNIT – I : Introduction to CATIA	09 Hours
• Overview of CATIA interface and functionalities. • Basics of 2D sketching: creating and editing sketches. • Constraints and dimensions in sketches. • Simple sketch-based features: extrude, revolve, and sweep.	
UNIT – II: Part Design Fundamentals	09 Hours
• Introduction to part design workbench.	

- Creating and modifying basic solid features: pads, pockets, shafts, and grooves. - Boolean operations: add, subtract, and intersect. - Creating complex geometries using multi-section solid features.	
UNIT – III: Assembly Design	06 Hours
- Introduction to assembly workbench and its interface. - Creating and managing assembly components. - Applying constraints to assemble parts accurately. - Techniques for managing large assemblies.	
UNIT – IV: Surface Design	07 Hours
- Introduction to generative shape design workbench. - Creating and editing basic surfaces: extrude, revolve, sweep, and loft. - Surface operations: trim, split, join, and fillet. - Advanced surface modeling techniques.	
UNIT – V: Drafting and Documentation	08 Hours
- Introduction to drafting workbench and its tools. - Creating standard views from 3D models. - Adding dimensions, annotations, and symbols to drawings. - Generating bill of materials (BOM) and creating detailed engineering drawings.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Create and manipulate complex 2D sketches and 3D models using CATIA's sketching and part design tools to meet specific design requirements.	L2 & L3
2	Construct and optimize intricate assemblies by applying appropriate constraints and managing large assemblies efficiently within CATIA.	L2 & L3
3	Design and refine advanced surface models, employing a variety of surface operations to achieve precise and complex geometries.	L3
4	Generate and evaluate comprehensive engineering drawings and documentation, ensuring accuracy and adherence to industry standards using CATIA's drafting tools.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2		2				1					
CO2	3	2	2		2				1					
CO3	3	2	2						1					
CO4	3	2	2		2				1					

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. Tickoo Sham, (2016)"CATIA V5-6R2015 Basics: Sketcher, Part, and Assembly Design"
CADCIM Technologies,.

Reference Books:

1. Richard Cozzens (2013) "CATIA V5 Workbook Release V5-6R2013", SDC Publications.

Skill Enhancement Course-III CAE LAB-II (ANSA) [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 13+26 Hours
L–T–P–S	: 1–0–2–0		
Course Learning Objectives: This Course will enable students to: 2. Enable students to learn and apply ANSA – a finite element pre-processor for industry problems 3. Enable students to learn the process for complex FEM (Finite Element Modelling) for structural and CFD analyses using 2D & 3D elements for selected industry problems, including how to model mechanical joints (welds, bolts, rivets etc.), mid-surface extraction, joining of different sub-systems, basic quality checks etc. 4. Full model checks as per the industry standards			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

UNIT – I	09 Hours
• Introduction to FEA Overview of FEA with some basic examples and explaining the importance of mathematical model generation to carry out different analyses • Reading and translation of CAD files and introduction to TOPO menu Main terms of TOPO Menu, changing FEM disciplines between different menus, Geometry clean up, preparing model for surface meshing, switch to Mesh menu and explain about some basic options in Mesh menu ex: perimeters, macros, mesh generator etc. • Meshing for Sheetmetal and plastic parts	

Middle Surface Extraction approach like Skin and Casting, Mesh generation and Quality corrections	
UNIT – II	
09 Hours	
Introduction to Part Manager, Property and Material assignment Creating parts, groups and meta data carried from CAD software, assigning property and materials for entities • Handling of Sheetmetal features Identification of features like holes, stamps, beads etc, and definition of design actions, mesh treatment. Collaboration of feature manager with morphing module. • Connections of Parts Overview of connection manager, different types of weld representation (seam weld, spot weld), and bolt definition (both 1D and 3D) • Boundary condition for static load case Preparing model to carry out linear load case like SPC, load definition (point load and distributed load), header creation and output the file in industry standard solver format	
UNIT – III	
06 Hours	
Tetrahedral and Hexahedral mesh generation Typical solid parts demonstration to generate 2D tria mesh and convert them to tetra mesh. Overview of map, extrude, solid build options and mesh quality corrections.	
UNIT – IV	
07 Hours	
Hybrid mesh generation for CFD external aerodynamics Geometry healing, batch mesh scenarios, quality corrections, mesh refining process like size box and layer generation. Overview of interfaces using property cards. 3D model generation with solution details.	
UNIT – V	
08 Hours	
•Morphing module for design modifications DFM (Direct Fit Morphing) options like rotate, translate, glide, sweep etc for external aerodynamics 2D mesh model • Coupling of ANSA with optimizers Creation of parameters, DOE (Design of Experiments) for linear cases	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	•Apply FEA principles to read, translate, and prepare CAD models for meshing, including geometry cleanup and mesh generation for sheet metal and plastic parts.	L2 & L3
2	Design and manage parts using modeling tool, including property and material assignment, handling sheet metal features, and defining connections such as welds and bolts.	L2 & L3
3	Generate tetrahedral and hexahedral meshes for solid parts, perform quality corrections, and apply hybrid mesh generation techniques for CFD external aerodynamics.	L3

4	Utilize the morphing module for design modifications and integrate CATIA with optimizers to perform design of experiments (DOE) for linear cases.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2		2				1					
CO2	3	2	2		2				1					
CO3	3	2	2						1					
CO4	3	2	2		2				1					
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

Reference Book:

1: ANSA version 22 Tutorial Guide - 2021

PROFESSIONAL ELECTIVE-1

Sensors & Actuators [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L–T–P–S	: 3–0–0–0		
Course Learning Objectives: This Course will enable students to: 1. Understand the fundamental principles and characteristics of various sensors and actuators used in mechanical systems. 2. Analyze the performance parameters and control mechanisms of sensors and actuators to optimize their applications in engineering solutions. 3. Explore advanced sensor technologies and their integration into mechanical systems for enhanced functionality and reliability. 4. Evaluate the theoretical aspects of sensor and actuator networks, including smart sensors and IoT applications in mechanical engineering. 5. Critically assess real-world case studies to understand the practical implications and ethical considerations of deploying sensors and actuators in industry.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. ● Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. ● Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. ● Show Video/animation films to explain functioning of various concepts. ● Encourage Collaborative (Group Learning) Learning in the class. ● To make Critical thinking, ask at least three Higher order Thinking questions in the class. ● Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. ● Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. ● Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

UNIT – I : Principles of Sensors	09 Hours
Introduction to Sensors: Definitions, classifications, and roles in mechanical systems. Sensor Characteristics: Accuracy, sensitivity, range, resolution, and repeatability. Mechanical and Electromechanical Sensors: Emphasis on strain gauges, accelerometers, and pressure sensors. Theoretical Foundations: Understanding the physics and mechanics behind sensor operation.	
UNIT – II: Principles of Actuators	09 Hours
Introduction to Actuators: Overview of types and applications in mechanical engineering. Mechanical Actuators: Detailed theory on hydraulic, pneumatic, and electromechanical actuators. Performance Parameters: Force, speed, energy efficiency, and control characteristics. Theoretical Analysis: Studying the mechanical principles that govern actuator performance.	
UNIT – III: Sensor and Actuator Control Theory	06 Hours
Control Systems Overview: Basics of control theory relevant to sensors and actuators. Feedback and Feedforward Control: Understanding how these systems are applied in mechanical contexts. Dynamic Behavior of Actuators: Modeling and simulation of actuators under various control strategies. Theoretical Exercises: Analyzing control system designs through theoretical problems and simulations.	
UNIT – IV: Advanced Sensor Technologies	07 Hours
Smart Sensors and IoT: Concepts of smart sensors, integration with IoT, and implications for mechanical systems. Wireless Sensor Networks (WSN): Theoretical basis for design and implementation of WSNs. Sensor Fusion: Techniques for combining multiple sensor outputs to improve accuracy and reliability. Discussion on Emerging Technologies: Focus on MEMS, nanosensors, and their impact on mechanical engineering.	
UNIT – V: System Integration and Case Studies	08 Hours
Designing Integrated Systems: Theoretical approaches to integrating sensors and actuators into mechanical systems. Case Studies: Examination of real-world applications in automotive, aerospace, and industrial automation. Ethical and Environmental Considerations: Discussing the implications of sensor and actuator technology in mechanical engineering. Review and Future Trends: Exploring current research and future directions in sensor and actuator technology.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply knowledge of sensor and actuator characteristics to select appropriate technologies for specific mechanical engineering applications.	L2 & L3
2	Design and analyze control systems for actuators using advanced control theories to ensure optimal performance in mechanical setups.	L2 & L3
3	Integrate and configure smart sensors and wireless networks in mechanical systems, demonstrating an understanding of complex system requirements and functionalities.	L3

4	Synthesize information from diverse sensor inputs through sensor fusion techniques to improve system accuracy and reliability in engineering projects.	L4
5	Critique and propose improvements to existing sensor and actuator systems in mechanical engineering case studies, focusing on sustainability and ethical considerations.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	1	1	1	2	2	1	1	3	2
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	2	3	-	-	2	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	2
CO5	3	2	3	-	-	2	1	2	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. Clarence W. de Silva (2015). "Sensors and Actuators: Engineering System Instrumentation", CRC Press, 2nd Edition.
2. W. Bolton, (2015) "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", Pearson, 6th Edition.

References:

1. David G. Alciatore and Michael B. Hstand (2018) "Introduction to Mechatronics and Measurement Systems", McGraw-Hill Education, 5th Edition.
2. Placko, D. (Ed.). (2013). Fundamentals of instrumentation and measurement. John Wiley & Sons.

AUTOMATED MANUFACTURING SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L–T–P–S	:	3–0–0–0			
Course Learning Objectives: This Course will enable students to: 1. Introduce students to the fundamental concepts and components of automated manufacturing systems. 2. Provide knowledge on the configuration, programming, and control of industrial robots. 3. Explain the principles and implementation of computer-integrated manufacturing systems. 4. Teach the design and application of various automated material handling systems. 5. Equip students with the skills to apply quality control and monitoring techniques in automated manufacturing environments.					
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.					
UNIT – I : Introduction to Automated manufacturing Systems					09 Hours
Overview of manufacturing systems. Evolution and types of automation. Key components of automated systems. Role of automation in manufacturing. Economic and strategic importance					
UNIT – II: Industrial Robotics and Automation					09 Hours
Basics of industrial robotics. Robot configurations and applications. Robotic work cells and their integration. Programming and controlling robots. Safety and maintenance of robotic systems					

UNIT – III: Computer-Integrated Manufacturing (CIM)	06 Hours
Concepts of CIM. Components of CIM: CAD, CAM, and CAPP. CIM architecture and data flow Integration of CIM with ERP and MES. Benefits, challenges, and case studies	
UNIT – IV: Automated Material Handling Systems	07 Hours
Types of material handling systems. Automated storage and retrieval systems (AS/RS). Conveyors, AGVs, and industrial trucks. Design principles and implementation. Case studies and applications	
UNIT – V: Quality Control and Monitoring in Automated Systems	08 Hours
Principles of quality control in manufacturing. Automated inspection and testing techniques. Role of sensors and data acquisition systems. Statistical process control (SPC) and its applications. Quality management systems (QMS)	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Design and integrate key components of automated manufacturing systems.	L2 & L3
2	Program and control industrial robots for various applications.	L2 & L3
3	Implement computer-integrated manufacturing systems, including CAD, CAM, and CAPP.	L3
4	Develop automated material handling systems using AS/RS, conveyors, and AGVs.	L4
5	Apply quality control techniques and statistical process control in automated systems.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	2	-	-	1	1	1	2	2	1	1	3	2
CO3	3	2	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	2	-	-	1	1	1	2	2	1	1	2	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks

1. Mikell P. Groover (2014) "Automation, Production Systems, and Computer-Integrated Manufacturing" 4th edition Pearson.
2. John J. Craig (2017) "Introduction to Robotics: Mechanics and Control" Pearson Education.

Reference Books

1. Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2009). Robotics: Modelling, Planning and Control. Springer.
2. Groover, M. P. (2020). Fundamentals of Modern Manufacturing: Materials, Processes, and Systems (6th ed.). Wiley.

INTRODUCTION TO HYBRID & ELECTRIC VEHICLES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This course will enable students to:

1. Explain the basics of electric and hybrid electric vehicles, their architecture
2. Discuss the design and component sizing and the power electronics devices used in electric and hybrid electric vehicles.
3. Analyse various electric drives suitable for electric and hybrid electric vehicles.
4. To help the students for understanding the concept of powertrain sizing and energy management system
5. Understanding of different energy storage technologies and power electronics system used for electric and hybrid electric vehicles

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I	09 Hours
HYBRID VEHICLE ARCHITECTURE: Introduction - Concept of Hybrid Electric Drivetrains - Architectures of Hybrid Electric Drivetrains - Series and Parallel Hybrid Electric Drivetrains – Coupling Modes - Operating Modes – Hybridization factor – PHEV – Performance characteristics Electric Vehicle Architecture: Introduction- Configurations - Traction Motor Characteristics - Tractive Effort and Transmission Requirement – Power Flow Control in Electric Drivetrain – Positioning of Motors – Vehicle Performance - Tractive Effort in Normal Driving - Energy Consumption – Single and Multi Motor drives.	
UNIT - II	9 Hours
POWERTRAIN COMPONENTS OF HYBRID AND ELECTRIC VEHICLES: Traction Motor Types – Configuration and Control - DC Motor- Brushless DC Motor – BLDC Motor Control - Switched Reluctance Motor – AC Induction – Motor Drives and Introduction to Power electronic components – Electronic Control Unit of Motors – Various Control Modes – Drive system Efficiency SIZING OF POWERTRAIN SYSTEMS: Fundamentals of Vehicle Propulsion – Vehicle Resistance – Basics - sizing and rating of powertrain components - Introduction to tractive force- torque and power - Basics and factors influenced on tractive force- torque and power (2w, 3w &4w) - Calculation of battery pack- motor torque and power requirements for EV-Case study – Operating fuel economy	
UNIT - III	06 Hours
POWERTRAIN ENERGY MANAGEMENT SYSTEM Introduction to energy management strategies - classification of energy management strategies -rule based and optimization strategies - real-time working of energy management system in HEV -model-based design and simulation process - Implementation issues of energy management strategies	
UNIT - IV	08 Hours
TRANSMISSION SYSTEM FOR HYBRID AND ELECTRIC POWERTRAIN: Need for transmission system in EV and HEV – Torque and Speed Matching - Design consideration of transmission system - Types and Procedure, Power Transmission – Power flow and management, Powertrain components for series -parallel - series-parallel hybrid- Power and Torque distribution- Types of transmission - Single Speed – Multi-speed transmission in EV-Planetary Gear box in HEV- Drive shaft in EV and HEV	
UNIT - V	07 Hours
ENERGY STORAGE SYSTEM AND POWER ELECTRONICS IN EV AND HEV Batteries – Ultracapacitor -Supercapacitor - Fuel Cells, and Controls - Flywheel Energy Storage - Hydraulic Energy Storage - Hybrid Fuel Cell Energy Storage. Power electronics including switching - AC-DC, DC-AC conversion - electronic devices and circuits used for control and distribution of electric power- Thermal Management of HEV Power Electronics	

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Analyze the architecture and performance characteristics of hybrid and electric vehicle drivetrains.	L4												
2	Evaluate the efficiency and control modes of different traction motors used in hybrid and electric vehicles.	L3												
3	Design and size powertrain components for hybrid and electric vehicles based on vehicle propulsion fundamentals and tractive force requirements.	L3												
4	Implement and optimize energy management strategies for hybrid and electric vehicle powertrains in real-time applications.	L4												
5	Assess the design considerations, power flow, and transmission systems used in hybrid and electric vehicles, including single and multi-speed transmissions and energy storage systems.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C03	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	2
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C06	3	3	2	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

TEXT BOOKS:

1. Callister, W. D., Jr. (2020). Materials Science and Engineering: An Introduction (2nd ed.). John Wiley & Sons, Inc.
2. Raghavan, V. (2019). Materials Science and Engineering. Prentice-Hall of India Pvt. Ltd.

REFERENCE BOOKS:

1. Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. M. (2018). Modern electric, hybrid electric, and fuel cell vehicles. CRC press
2. Denton, T. (2020). Electric and hybrid vehicles. Routledge

SOLAR ENERGY ENGINEERING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – V	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Estimate solar radiation using models and empirical methods 2. Explain the operation principles of various solar thermal collectors 3. Perform performance analysis of PV systems under different environmental conditions 4. Integrate energy storage solutions into solar energy systems, select appropriate storage technologies based on application requirements 5. Assess diverse applications of solar energy in heating, cooling, and power generation	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours
FUNDAMENTALS OF SOLAR ENERGY: Solar radiation basics: nature, composition, and solar constant, Geometric relations: incidence, azimuth, zenith angles, Solar radiation measurement techniques: pyranometers, pyrliometers, Models and methods for estimating solar radiation	
UNIT – II	08 Hours
SOLAR THERMAL ENERGY SYSTEMS: Types of solar collectors: flat-plate, evacuated tube, concentrating, Thermal performance metrics and efficiency parameters, Heat transfer mechanisms: conduction, convection, radiation, Design and optimization of solar thermal systems	

UNIT - III		06 Hours
SOLAR PHOTOVOLTAIC SYSTEMS: Photovoltaic (PV) principles: photoelectric effect, solar cell operation, Types of PV technologies: crystalline silicon, thin-film, emerging technologies, Components of PV systems: panels, inverters, batteries, Design and performance analysis of PV systems		
UNIT - IV		08 Hours
SOLAR ENERGY STORAGE AND CONVERSION: Thermal energy storage methods: sensible and latent heat storage, Electrical energy storage: battery technologies, Conversion technologies: converting stored solar energy, Integration strategies for enhanced system performance		
UNIT - V		09 Hours
APPLICATIONS AND ECONOMICS OF SOLAR ENERGY: Solar heating and cooling applications, Solar power generation: residential, commercial, utility-scale. Economic analysis: cost-benefit, payback period, LCOE Policy impact: government incentives, regulations		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Evaluate solar radiation data using empirical models and measurement techniques to optimize the orientation and tilt angles for maximum energy capture	L4
2	Develop detailed designs of solar thermal systems, considering factors such as collector type, thermal storage, and heat transfer mechanisms. Evaluate their performance and efficiency metrics under varying environmental conditions	L3
3	Implement advanced PV system designs incorporating different PV technologies (e.g., crystalline silicon, thin-film) and components (panels, inverters, batteries). Analyze and optimize their performance characteristics for residential, commercial, and utility-scale applications	L3
4	Apply knowledge of thermal and electrical energy storage technologies to integrate efficient energy storage solutions into solar energy systems. Analyze the effectiveness of conversion technologies in maximizing energy utilization	L4
5	Develop comprehensive strategies for the deployment of solar energy solutions in residential, commercial, and industrial sectors, considering economic viability, policy implications, and environmental sustainability	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	2	3	-	-	1	1	1	2	2	1	1	3	2
C05	3	3	3	-	-	2	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. S. P. Sukhatme, J K. Nayak (2017), Solar Energy, 4th Edition – McGraw Hill Education

REFERENCE BOOKS:

1. John A.Duffie, William A.Beckman (2013), Solar Engineering of Thermal Processes, John Wiley & Sons.
2. Garg H P, Prakash J (2013), Solar Energy – Fundamentals and Applications, Tata McGraw Hill

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ph14/preview
2. <https://archive.nptel.ac.in/courses/112/105/112105051/>

REFRIGERATION AND AIR CONDITIONING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This Course will enable students to:

1. Study the methods of refrigeration, Carnot cycle, Unit of refrigeration and coefficient of performance
2. Discuss classification and properties of refrigerants
3. Describe the Vapour compression and Vapour absorption systems
4. Understand psychrometric properties and processes
5. Study Air conditioning systems and air conditioning loads
6. Understand the measuring instruments and sensors used in air conditioning

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I	08 Hours
Methods of refrigeration, ice refrigeration, evaporative refrigeration, air refrigeration, vapour refrigeration, dry ice refrigeration, pulse tube refrigeration, thermo-acoustic refrigeration, reverse Carnot cycle, block diagram of refrigerator & modified reverse Carnot cycle (Bell Coleman cycle). Unit of refrigeration and coefficient of performance.	
UNIT – II	06 Hours
Refrigerants: Classification of refrigerants, desirable properties of refrigerants, environmental issues, Ozone depletion potential and global warming potential & life cycle climate	

performance. Selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes.	
UNIT – III	08 Hours
Vapour Compression Systems: Vapor compression cycle: p-h and T-s diagrams – deviations from theoretical cycle – sub cooling and super heating-effects of condenser and evaporator pressure on COP- multi pressure system – low temperature refrigeration – cascade systems – problems. Vapour Absorption Systems: Introduction, working of simple vapour absorption system, desirable properties of binary mixture (aqua-ammonia), Lithium-Bromide (Li- Br) absorption system, performance evaluation, applications and comparison between vapour compression system and vapour absorption system.	
UNIT – IV	08 Hours
Properties of moist air-Gibbs Dalton law, specific humidity, dew point temperature, degree of saturation, relative humidity, enthalpy, humid specific heat, wet bulb temperature thermodynamic wet bulb temperature, psychrometric chart; psychrometric processes.	
UNIT – V	09 Hours
Air conditioning: Introduction, Classification, ASHRAE Nomenclature, Applications, Different Air-Conditioning Systems: Central, Unitary, Window, Packaged & Transport Air conditioning loads: Outside and inside design conditions; Sources of heat loads and calculations; Air filters; air conditioning systems with controls: temperature, pressure and humidity sensors, actuators & safety controls.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze different refrigeration methods and evaluate their performance characteristics and applications.	L4
2	Classify refrigerants based on properties, environmental impact, and select suitable refrigerants for specific applications.	L3
3	Assess the performance of vapor compression and vapor absorption systems, including cycle deviations and efficiency improvements.	L3
4	Calculate properties of moist air using psychrometric principles and perform relevant psychrometric process calculations.	L4
5	Design various air conditioning systems by performing load calculations and integrating appropriate control mechanisms.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C03	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	2
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. Arora, C. P. (2008). Refrigeration and Air Conditioning. Tata McGraw-Hill.
2. Prasad, M. (1983). Refrigeration and Air Conditioning. Wiley Eastern Ltd.

REFERENCES BOOKS :

1. Dossat, R. J. (2000). *Principles of refrigeration* (S.I. version). Wiley Eastern Ltd.

MANAGEMENT AND ENTREPRENEURSHIP

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This course will enable students to:

1. Utilize management functions and planning steps to develop plans that achieve organizational goals. Students will practice applying these functions and steps in case studies and simulations to create effective organizational plans.
2. Describe how various organizational structures and staffing processes enhance operational efficiency. Students will explore different structures and staffing models, understanding their impact on efficiency through real-world examples.
3. Recall the principles of social responsibility and ethical practices in business. Students will list and memorize key principles, preparing them to recognize and discuss these concepts in business scenarios.
4. Explain how various strategies can enhance the performance and sustainability of small-scale industries. Through lectures and discussions, students will learn to articulate strategies that improve small-scale industry performance and sustainability.
5. Utilize project management tools and techniques to plan, execute, and evaluate successful projects. Students will engage in hands-on projects, using management tools to experience the full lifecycle of project management from planning to evaluation.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT – I Management and Planning	09 Hours
Management: Definition, Importance – Nature and Characteristics of Management, Management Functions, Roles of Manager, Levels of Management, Managerial Skills, Management & Administration, Management as a Science, Art & Profession. (Text Book-1: Chapter 1: 11 to 39). Planning: Nature, Importance and Purpose of Planning, Types of Plans, Steps in Planning, Limitations of Planning, Decision Making – Meaning, Types of Decisions- Steps in Decision Making. (Text Book-1: Chapter 2:69-125).	
UNIT – II: Organizing and Staffing	09 Hours
Organizing and Staffing: Meaning, Nature and Characteristics of Organization – Process of Organization, Principles of Organization, Departmentalization, Committees – meaning, Types of Committees, Centralization Versus Decentralization of Authority and Responsibility, Span of Control (Definition only), Nature and Importance of Staffing, Process of Selection and Recruitment. (Text Book-1: Chapter 4: -195-235).	
UNIT – III: Social Responsibilities of Business:	06 Hours
Social Responsibilities of Business: Meaning of Social Responsibility, Social Responsibilities of Business towards Different Groups, Social Audit, Business Ethics and Corporate Governance. Entrepreneurship: Definition of Entrepreneur, Importance of Entrepreneurship, concepts of Entrepreneurship, Characteristics of successful Entrepreneur, Classification of Entrepreneurs, Intrapreneur – An Emerging Class, Comparison between Entrepreneur and Intrapreneur, Myths of Entrepreneurship, Entrepreneurial Development models, Entrepreneurial development cycle, Problems faced by Entrepreneurs and capacity building (Text Book-1: Chapter 4:-(235- 301).	
UNIT – IV: Modern Small Business Enterprises:	07 Hours
Modern Small Business Enterprises: Role of Small-Scale Industries, Concepts and definitions of SSI Enterprises, Government policy and development of the Small-Scale sector in India, Growth and Performance of Small-Scale Industries in India, Sickness in SSI sector, Problems for Small Scale Industries, Impact of Globalization on SSI, Impact of WTO/GATT on SSIs, Ancillary Industry and Tiny Industry (Definition only). Institutional Support for Business Enterprises: Introduction, Policies & Schemes of Central-Level Institutions, State-Level Institutions. (Text Book-2)	
UNIT – V: Project Management:	08 Hours
Project Management: Meaning of Project, Project Objectives & Characteristics, Project Identification- Meaning & Importance; Project Life Cycle, Project Scheduling, Capital Budgeting, Generating an Investment Project Proposal, Project Report-Need and Significance of Report, Contents, Formulation, Project Analysis-Market, Technical, Financial, Economic, Ecological, Project Evaluation and Selection, Project Financing, Project Implementation Phase, Human & Administrative aspects of Project Management, Prerequisites for Successful Project Implementation. (Text Book-2)	
New Control Techniques- PERT and CPM, Steps involved in developing the network, Uses and Limitations of PERT and CPM. (Text Book-2)	

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Apply management principles to organize and lead teams effectively, making informed decisions and planning strategically to meet organizational goals.	L3												
2	Implement robust staffing and recruitment processes to build efficient organizational structures and enhance workforce capabilities.	L3												
3	Demonstrate a commitment to social responsibility and ethical practices in business, conducting social audits and promoting sustainable practices.	L4												
4	Analyze the impacts of globalization on small-scale industries and utilize institutional support to foster growth and mitigate challenges in the SSI sector.	L3												
5	Manage complex projects from inception to completion, using advanced techniques like PERT and CPM to optimize resources and achieve project objectives efficiently.	L4												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	2	1	2	3	2	2	1	3	2
CO2	2	3	2	-	-	1	1	1	3	2	2	1	3	2
CO3	2	2	2	-	-	3	3	3	2	2	1	1	3	3
CO4	3	3	2	-	-	2	1	1	2	2	2	1	3	3
CO5	3	3	3	-	-	1	1	1	3	2	2	1	3	2
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

Textbooks:

1. Koontz, H., & Weihrich, H. (2020). Management: Principles and Applications (14th ed.). McGraw-Hill Education.
2. Gray, C. F., & Larson, E. W. (2018). Project Management: The Managerial Process (7th ed.). McGraw-Hill Education.

Reference Books:

1. Kotler, P., & Lee, N. (2005). Corporate Social Responsibility: Doing the Most Good for Your Company and Your Cause (1st ed.). Wiley.
2. Longenecker, J. G., Petty, J. W., Palich, L. E., & Hoy, F. (2019). Small Business Management: Launching & Growing Entrepreneurial Ventures (18th ed.). Cengage Learning.

FINITE ELEMENT ANALYSIS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	:		Credits	:	04
Hours / Week	:	05 Hours	Total Hours	:	39+26 Hours
L-T-P-S	:	3-0-2-0			

Course Learning Objectives:

This course will enable students to:

1. Understand the fundamental principles and applications of computational methods like finite difference and finite volume methods in engineering analysis.
2. Develop proficiency in creating and manipulating element matrices for analyzing various physical phenomena including torsion, fluid flow, and heat transfer.
3. Gain practical skills in applying principles of virtual work, variational methods, and Galerkin's method to solve real-world engineering problems.
4. Master the use of finite element analysis for structural evaluation, including trusses, beams, and axi-symmetric stress analysis.
5. Learn to effectively utilize commercial finite element method (FEM) software for dynamic analysis, numerical integration, and error analysis.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I	09 Hours
Introduction to computational methods, Finite difference method, Finite volume methods, Direct stiffness method, Integral formulation for numerical Solution – Variational method, Method of weighted residuals, Potential energy formulations; Principle of virtual work, Division of the region into elements - One dimensional linear element, Linear triangular element, Bilinear rectangular element, Representation for scalar and vector fields, Global, local and natural coordinate systems in one, two and three dimensions.	
UNIT - II	09 Hours
Governing differential equations; Integral equations for the element matrices, Triangular element matrix, Torsion of noncircular sections, General theory – Twisting of a square bar, Shear stress components, Evaluation of the twisting torque, Flow of an Ideal Fluid – Potential Formulation, Groundwater Flow, Flow Around a Cylinder, Other field problems, Derivative boundary conditions – 1D, Derivative boundary conditions – 2D,	
UNIT - III	06 Hours
Heat transfer by conduction, The one dimensional fin – 1, The one dimensional fin –2, The composite walls, The two-dimensional fin, Boundary conditions, Long two-dimensional bodies – 1, Long two-dimensional bodies – 2, Axi-symmetric field problems, The differential equation – Axi-symmetric elements, Galerkin's method, Element matrices,	
UNIT - IV	07 Hours
The axial force member - Element matrices, The truss element – Element matrices, Analysis of a pinned truss – 1, Analysis of a pinned truss – 2, A Beam element, Shape functions, Element matrices, Analysis of a statically indeterminate beam – 1, Analysis of a statically indeterminate beam – 2, A plane frame element – Element matrices, Two dimensional stress analysis - Stress, strain and Hooke's Law, The strain displacement equations, Two dimensional elasticity - Plane stress and plane strain, The displacement equations, The element matrices, Element stresses, Axi-symmetric stress analysis - Element matrices, Surface loads,	
UNIT - V	08 Hours
Iso-parametric elements in one and two dimensions, use of higher order elements, Element matrices, Introduction to Transient domain & Dynamic analysis, Changing the variables of integration- One-dimensional integrals, Two- dimensional integrals, Numerical Integration techniques- one-dimensional integrals, Quadrilateral regions, Triangular regions; Evaluating [B]; Evaluating the surface integrals, Pre and post processing, capability of commercially available FEM packages, Error analysis	
List of Laboratory/Practical Experiments activities to be conducted (if any) :28	
1.	Bars of constant cross section area, tapered cross section area and stepped bar
2.	Trusses (Minimum 2 exercises) Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc; (Minimum 6 exercises)
3.	Dynamic analysis - Fixed – fixed beam for natural frequency determination - Bar subjected to forcing function - Fixed – fixed beam subjected to forcing function
	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises)

4.	Stress analysis of a rectangular plate with a circular hole

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply finite element methods such as finite difference and finite volume methods to solve complex engineering problems involving scalar and vector fields.	L3
2	Develop and analyze element matrices and use computational techniques to evaluate torsion in non-circular sections and fluid flow scenarios.	L3
3	Utilize advanced numerical methods to analyze heat transfer through various geometrical configurations, including fins and composite walls.	L4
4	Implement structural analysis on trusses, beams, and frames using element matrices and evaluate the resulting stress and strain using Hooke's Law.	L3
5	Perform dynamic and transient analysis using isoparametric elements and numerical integration techniques, ensuring accurate pre and post-processing in commercial FEM software.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C05	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C06	3	3	3	-	3	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Segerlind, L. J (2006). Applied Finite Element Analysis. John Wiley and Sons.
2. Ramamurthy, G. (2009). Applied Finite Element Analysis. I.K. International Publishing House.

Reference Books:

1. Cook, R. D., Malkus, D. S., Plesha, M. E., & Witt, R. J. (2007). Concepts and Applications of Finite Element Analysis (4th ed., 1st reprint). Wiley Student Edition.
2. Rao, S. S. (2007). The Finite Element Method in Engineering. Butterworth-Heinemann (An imprint of Elsevier), Published by Elsevier India Pvt. Ltd.

MECHANICAL VIBRATIONS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	:		Credits	:	03
Hours / Week	:	04 Hours	Total Hours	:	26+26 Hours
L-T-P-S	:	2-0-2-0			

Course Learning Objectives:

This course will enable students to:

1. Understand the fundamental principles of vibration in mechanical systems, including natural frequencies, damping, and the effects of vibration.
2. Master the analysis of forced and free vibrations in single and multiple degree of freedom systems with and without damping.
3. Develop skills in designing and optimizing vibration absorbers and isolators for mechanical systems to reduce the impact of vibrations.
4. Gain proficiency in applying numerical methods for the analysis of torsional vibrations and critical speeds in complex mechanical assemblies.
5. Learn to use modern vibration measurement tools and AI-based techniques for condition monitoring and fault diagnosis in engineering applications.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I		05 Hours
Introduction, classification of vibration systems, harmonic motion, natural frequency & response, effects of vibration, superposition of simple harmonic motions, Single degree freedom system-equation of motion, Free vibration, equivalent systems, torsional vibrations, vibrations of systems with viscous damping, Logarithmic decrement, energy dissipation in viscous damping.		
UNIT - II		06 Hours
Forced vibration, harmonic excitation with viscous damping, steady state vibrations, forced vibrations with rotating and reciprocating unbalance, support excitation, vibration isolation, transmissibility, displacement, velocity and acceleration measuring instruments.		
UNIT - III		05 Hours
Introduction, principal modes, torsional system with damping, coupled system, principle of vibration absorber, undamped dynamic vibration absorbers, torsional vibration absorber, centrifugal pendulum absorbers, vibration isolators and dampers.		
UNIT - IV		05 Hours
Numerical Analysis- Influence coefficients, reciprocal theorem, torsional vibration of multi-degree rotor system, Rayleigh's method, Dunkerely's, Holzer's and Stodola methods, Rayleigh-Ritz method, critical speed of shafts, whirling of uniform shaft, shaft with one disc with and without damping, multi-disc shafts, secondary critical speed.		
UNIT - V		05 Hours
Vibration instruments – transducer, vibrometer, accelerometer, seismometer, vibration pickup, proximity probe spectrum analyzer, principle of seismic instruments, frequency measuring instruments, diagnostic tools, Introduction to condition monitoring and fault diagnosis using Artificial Intelligence approach.		
List of Laboratory/Practical Experiments activities to be conducted (if any) :26		
1.	Plotting and analysis of various graphs of free and forced vibrations using	
2.	MATLAB.	
3.	Virtual lab exercises provided by MHRD	
4	Free and forced vibration	
5.	Whirling of the shaft and finding the critical speed of the shaft.	
6.	Students will be trained in MATLAB and ANSYS for solving simple vibration problems and using AI & ML techniques in condition monitoring.	

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Analyze and model single and multi-degree freedom systems to understand their natural frequencies, responses, and damping characteristics.	L3												
2	Design and evaluate vibration isolation systems and absorbers to mitigate unwanted vibrations in mechanical systems.	L3												
3	Apply numerical methods such as Rayleigh's, Dunkerley's, Holzer's, and Stodola's methods to analyze torsional and critical speed vibrations in complex rotor systems.	L4												
4	Utilize advanced vibration measuring instruments like vibrometers, accelerometers, and spectrum analyzers to assess and interpret vibration data.	L3												
5	Implement AI-based condition monitoring and fault diagnosis techniques to predict and prevent failures in mechanical systems.	L4												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
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C03	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C05	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C06	3	3	3	-	3	1	1	1	2	2	1	1	3	3

Textbooks:

1. Rao, S. S. (2018). Mechanical Vibrations (6th ed.). Pearson Education Inc.
2. Thomson, W. T. (2001). Theory of Vibration with Applications (5th ed.). Prentice Hall.

References:

1. Rao, J. S., & Gupta, K. (1999). Introductory Course on Theory and Practice of Mechanical Vibrations. New Age International.
2. Ramamurthi, V. (2000). Mechanical Vibration Practice with Basic Theory (1st ed.). Narosa Publishing House.

MINOR PROJECT [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VI			
Subject Code	:	Credits	: 02
Hours / Week	: 03 Hours	Total Hours	: Hours
L-T-P-S	: 0-0-0-4		
Course Learning Objectives: This Course will enable students to: 1. Develop the ability to identify and define a relevant engineering problem through a comprehensive literature review and analysis. 2. Apply theoretical knowledge and practical skills to design and implement a feasible solution to the identified problem. 3. Enhance teamwork, communication, and project management skills by collaborating effectively with peers and faculty advisors. 4. Demonstrate innovation and creativity in the development and presentation of the project, including the preparation of detailed documentation and reports.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
Minor Project Content			
Students focuses on developing the ability to identify and define relevant engineering problems through comprehensive literature reviews and analysis. Students will apply theoretical knowledge and practical skills to design and implement feasible solutions to the identified problems. Emphasis will be placed on enhancing teamwork, communication, and project management skills by encouraging effective collaboration with peers and faculty advisors. The course will also promote innovation and creativity in project development and presentation, requiring students to prepare detailed documentation and reports to demonstrate their findings and solutions.			

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Identify and define a relevant engineering problem through comprehensive literature reviews and critical analysis.	L3												
2	Design and implement a feasible solution to the identified engineering problem using theoretical knowledge and practical skills.	L3												
3	Collaborate effectively with peers and faculty advisors, demonstrating enhanced teamwork, communication, and project management skills.	L4												
4	Prepare and present detailed project documentation and reports, showcasing innovation and creativity in the development and execution of the project.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3										2		3
CO2	3	3	2									2		3
CO3	3	3										1		3
CO4	3	3	2									2		3
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

INTERNSHIP [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code	:	Credits	: 02
Hours / Week	:	Total Hours	:
L-T-P-S	:	-----	
Course Learning Objectives: This Course will enable students to: 1. Provide hands-on industry experience to apply mechanical engineering concepts in real-world scenarios. 2. Develop practical skills and technical expertise through active participation in engineering projects. 3. Enhance professional skills, including communication, teamwork, and project management. 4. Foster an understanding of workplace dynamics and professional ethics in an engineering environment.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
Internship Content The internship start with an introduction to the objectives, expectations, workplace safety, professional behavior, and ethics, along with an overview of the host organization and its projects. Students were to receive training on industry-specific tools, software, and equipment, gaining hands-on experience in mechanical design, analysis, and manufacturing processes. Active involvement in ongoing engineering projects was intended to allow students to apply theoretical knowledge to practical tasks and problem-solving. Throughout the internship, students were expected to enhance their communication, teamwork, and leadership skills through group projects, meetings, presentations, and reports. They would also gain exposure to project management practices such as planning, scheduling, and resource allocation. Continuous assessment through supervisor feedback and self-reflection was to ensure progress. The internship was to culminate with the preparation of a			

comprehensive report detailing experiences, skills acquired, and project contributions, and a final presentation summarizing the internship outcomes and key learnings.

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Apply mechanical engineering theories to solve practical problems in a professional setting.	L3												
2	Demonstrate technical proficiency with industry-specific tools, software, and equipment.	L3												
3	Develop effective communication and teamwork skills through collaborative projects and professional interactions.	L4												
4	Analyze and evaluate engineering projects, preparing detailed reports and presentations on work and findings.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3										2		3
CO2	3	3	2									2		3
CO3	3	3										1		3
CO4	3	3	2									2		3

OPEN ELECTIVES-1

FLUID AND THERMAL ENGINEERING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Acquire an understanding of the fundamental principles of fluid mechanics and heat transfer and their relevance in various engineering contexts. 2. Develop the ability to analyze fluid behavior under different static and dynamic conditions using basic fluid dynamics principles. 3. Learn the methods of heat transfer, including conduction, convection, and radiation, and their applications in real-world scenarios. 4. Gain skills in evaluating and designing simple heat exchanger systems and understanding the factors affecting their performance. 5. Understand the environmental impacts of fluid and thermal systems and explore strategies for enhancing energy efficiency and sustainability in their design and operation.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction to Fluid Mechanics	06 Hours
Fundamentals of Fluid Mechanics: Properties of fluids, concept of viscosity, Newtonian and non-Newtonian fluids. Fluid Statics: Pressure variation in a fluid at rest, hydrostatic force on submerged surfaces, buoyancy and flotation. Fluid Dynamics: Concepts of flow visualization, streamlines, pathlines, streaklines, continuity equation, and Bernoulli's equation.	

UNIT – II: Fluid Flow Systems	10 Hours
Laminar and Turbulent Flow: Characteristics of laminar vs. turbulent flow, Reynolds number. Internal Flow: Flow through pipes, Darcy-Weisbach equation, friction factor, minor losses. External Flow: Drag and lift forces, flow around submerged objects like spheres and cylinders.	
UNIT – III: Heat Transfer Fundamentals	10 Hours
Modes of Heat Transfer: Conduction, convection, and radiation; understanding and application of each mode in engineering. Conduction: Fourier's law, thermal conductivity, heat transfer in steady and unsteady states. Convection: Newton's law of cooling, natural vs. forced convection, heat transfer coefficients.	
UNIT – IV: Applied Heat Transfer	07 Hours
Radiation Heat Transfer: Basic principles, black and grey surfaces, view factors, radiation exchange between surfaces. Heat Exchangers: Types of heat exchangers, overall heat transfer coefficient, effectiveness-NTU method. Phase Change Heat Transfer: Boiling, condensation, heat transfer during phase changes.	
UNIT – V: Thermal System Analysis	08 Hours
Thermodynamics and Thermal Systems: Review of first and second laws of thermodynamics, applications in real-world thermal systems. Energy Efficiency: Analysis of energy consumption, strategies for improving energy efficiency in thermal systems. Environmental Impact of Thermal Systems: Understanding the environmental aspects and sustainability considerations in the design and operation of thermal systems.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the principles of fluid mechanics to analyze and predict the behavior of fluids in both static and dynamic conditions.	L3
2	Design and evaluate systems involving internal and external fluid flows, considering factors like friction, drag, and lift.	L3
3	Utilize knowledge of conduction, convection, and radiation to solve practical heat transfer problems across various engineering applications.	L4
4	Analyze and optimize heat exchangers using the effectiveness-NTU method and assess phase change phenomena in thermal systems.	L3
5	Implement energy-efficient and environmentally sustainable practices in the design and operation of fluid and thermal systems.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	2	2	2	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Çengel, Y. A., & Cimbala, J. M. (2006). Fluid Mechanics: Fundamental and Applications. Tata McGraw-Hill Publishing Co. Ltd.
2. Çengel, Y. A., & Ghajar, A. J. (2014). Heat and Mass Transfer: Fundamentals and Applications (5th ed.). McGraw-Hill Education.

Reference Books:

1. Moran, M., Shapiro, H., Munson, B., & DeWitt, D. (2003). Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer. Wiley.
2. White, F. M. (2016). Fluid Mechanics (8th ed.). McGraw-Hill Education.

E-Resources:

20. <https://open.umn.edu/opentextbooks/textbooks/85>
21. <https://library.iitd.ac.in/index.php/node/81851>
22. [IC engine Major Parts and Its Function, Materials, Images, Manufacturing Method. \(learnmech.com\)](#)
23. [NPTEL :: Mechanical Engineering - NOC:IC Engines and Gas Turbines](#)

MATERIALS FOR ENGINEERING APPLICATIONS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This Course will enable students to:

1. Understand the basic classification and properties of engineering materials including metals, ceramics, polymers, and composites.
2. Gain proficiency in testing and characterizing material properties such as tensile strength, thermal conductivity, and electrical resistivity.
3. Acquire knowledge of materials suitable for high-temperature applications and their roles in industries like aerospace and power generation.
4. Learn the criteria for selecting materials for electronics and computing, including conductors, insulators, and semiconductor materials.
5. Explore the composition, advantages, and manufacturing processes of composite materials and their applications across various sectors.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I : INTRODUCTION TO ENGINEERING MATERIALS	06 Hours
An overview of the significance of materials in engineering, Classification of engineering materials based on their properties, such as metals, polymers, ceramics, and composites. Material properties and their importance in engineering design and applications.	
UNIT – II: MATERIAL PROPERTIES AND TESTING	10 Hours
Mechanical properties, including tensile strength, hardness, elasticity. Thermal properties, such as thermal conductivity and coefficient of thermal expansion. Electrical properties, including electrical conductivity and resistivity.	
UNIT – III: MATERIALS FOR HIGH-TEMPERATURE APPLICATIONS	10 Hours

High-temperature materials are essential in various engineering fields. This module focuses on: Materials that exhibit resistance to high temperatures, including refractory materials and super alloys. Applications of high-temperature materials in industries such as aerospace, power generation, and metallurgy. Thermal management materials used to dissipate heat effectively in electronic devices and other applications.

UNIT - IV: MATERIALS FOR ELECTRONICS AND COMPUTING

07 Hours

Conducting materials, such as metals and semiconductors, used in electronic circuits. Insulating materials to isolate and protect electronic components. Materials for electronic components, including resistors, capacitors, and semiconductors. Real-world case studies highlighting materials used in microprocessors and memory devices.

UNIT - V: COMPOSITE MATERIALS

08 Hours

The concept of composite materials and their composition. Advantages and disadvantages of composites. Applications of composites in various industries, including aerospace, automotive, and sports equipment. An overview of manufacturing processes for composites, including layup techniques and curing methods.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Evaluate and select appropriate engineering materials based on their mechanical, thermal, and electrical properties for specific engineering applications.	L3
2	Assess the suitability of materials for high-temperature environments, utilizing knowledge of refractory materials and superalloys in critical industry applications.	L3
3	Analyze the selection and use of specialized materials in electronics and computing, ensuring optimal functionality and efficiency in circuit design and component integration.	L4
4	Design and implement applications utilizing composite materials, considering their unique properties and manufacturing processes to optimize performance in industries like aerospace and automotive.	L4
5	Apply theoretical knowledge of material properties in practical scenarios to innovate and improve material selection and usage in engineering projects.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Callister, W. D., Jr., & Rethwisch, D. G. (2020). Materials Science and Engineering: An Introduction (10th ed.). Wiley.
2. Budinski, K. G., & Budinski, M. K. (2012). Engineering Materials: Properties and Selection (9th ed.). Prentice Hall.

Reference Books:

1. Ashby, M. F. (2017). Materials Selection in Mechanical Design (5th ed.). Butterworth-Heinemann.
2. Callister, W. D., Jr., & Rethwisch, D. G. (2020). Fundamentals of Materials Science and Engineering: An Integrated Approach (5th ed.). Wiley.

INDUSTRIAL ROBOTICS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Understand the fundamental principles, components, and classifications of industrial robots and their applications in various industries. 2. Develop the ability to analyze robot kinematics and dynamics for designing and optimizing robotic movements and tasks. 3. Acquire skills in programming industrial robots using various control strategies and understanding the integration of sensors and feedback mechanisms. 4. Apply knowledge of robotics to real-world industrial applications, focusing on automation in manufacturing and exploring robotics in non-traditional sectors. 5. Explore future trends in robotics, including the use of collaborative robots and the integration of artificial intelligence, to stay abreast of technological advancements.	
<u>Teaching-Learning Process (General Instructions)</u> These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction to Industrial Robotics	06 Hours
Overview of Industrial Robotics: History, evolution, and current trends in robotic technology. Types of Robots: Differentiate between articulated, SCARA, delta, and Cartesian robots based on structure and application areas. Robot Components: Detailed study of robot components including actuators, sensors, end-effectors, and controllers.	
UNIT – II: Robot Kinematics and Dynamics	10 Hours

Fundamentals of Kinematics: Introduction to kinematic chains, degrees of freedom, and robot motion analysis. Forward and Inverse Kinematics: Mathematical modeling to describe robot positions and orientations. Robot Dynamics: Understanding the forces and torques acting on robotic systems during movement.

UNIT - III: Robot Control Systems

10 Hours

Control Strategies: Overview of point-to-point control, continuous path control, and adaptive control.

Programming Robots: Introduction to robot programming languages and offline programming techniques. Sensors and Feedback: Role of sensors in robotics, sensor types, and their applications for feedback in robotic systems.

UNIT - IV: Applications of Industrial Robots

07 Hours

Robot Applications in Manufacturing: Automation of welding, assembly, painting, and material handling. Advanced Applications: Introduction to robots in non-manufacturing sectors such as healthcare, military, and service industries. Safety and Ergonomics: Understanding the safety protocols and human-robot interaction considerations in industrial settings.

UNIT - V: Future Trends and Innovations in Robotics

08 Hours

Collaborative Robots (Cobots): Exploring the capabilities and applications of cobots in industrial environments. Integration of AI and Machine Learning: How AI is being integrated into robotic systems to enhance functionality and decision-making. Sustainability and Robotics: Discussion on the environmental impact of robotics and sustainable practices in robot design and deployment.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply robotic kinematics and dynamics principles to design and implement effective robotic solutions for industrial applications.	L3
2	Program and control industrial robots using various programming languages and control systems to automate tasks effectively.	L3
3	Evaluate the integration of sensors and feedback systems in robotic applications to enhance operational accuracy and efficiency.	L3
4	Design and assess safety and ergonomic aspects of robot applications to ensure compliance with industry standards and enhance human-robot interaction.	L4
5	Implement collaborative robots and AI technologies in industrial settings, demonstrating an understanding of advanced robotics systems and their potential impacts.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Craig, J. J. (2017). *Introduction to Robotics: Mechanics and Control* (4th ed.). Pearson.
2. Mittal, R. K., & Nagrath, I. J. (2003). *Robotics and Control*. Tata McGraw-Hill Education.

Reference Books:

1. Janakiraman, P. A. (2009). *Robotics (Industrial Robotics)* (1st ed.). PHI Learning Pvt. Ltd.
2. Siciliano, B., & Khatib, O. (Eds.). (2016). *Handbook of Robotics* (2nd ed.). Springer.

Drives & Control systems [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code	:	Credits	03
Hours / Week	: 03 Hours	Total Hours	39 Hours
L-T-P-S	: 3-0-0-0		
Course Learning Objectives: This Course will enable students to: 1. Understand the fundamental principles and applications of various mechanical and electrical drive systems used in mechanical engineering. 2. Gain knowledge of power electronics including converters, inverters, and their role in drive systems. 3. Acquire skills in selecting and applying appropriate motor control techniques for different types of motors used in mechanical systems. 4. Learn to integrate hydraulic, pneumatic, and electrical control systems into mechanical designs for enhanced functionality. 5. Explore advanced control strategies and the latest technologies in drive systems to prepare for future challenges in mechanical engineering.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the realworld - and when that's possible, it helps improve the students' understanding.			
UNIT – I: Introduction to Drive Systems			09 Hours
Overview of Drive Systems: Role and types of drives in mechanical systems. Mechanical Drives: Study of belt, chain, and gear drives, focusing on their characteristics, applications, and selection criteria. Electrical Drives: Basics of electrical drive systems, including AC and DC drives,			

UNIT – II: Power Electronics in Drive Systems		09 Hours
Introduction to Power Electronics: Role of power electronics in controlling and driving mechanical systems. Semiconductor Devices: Thyristors, TRIACs, DIACs, and power transistors. Converters and Inverters: Basic circuits and their applications in drive systems, focusing on voltage and current control.		
UNIT – III: Electric Motor Control		06 Hours
Types of Motors: Induction, stepper, servo, and DC motors. Motor Starting Methods: Direct-on-line, star-delta, autotransformer, and electronic starters. Speed Control Methods: Various techniques for controlling motor speed, vector control and direct torque control.		
UNIT – IV: Control Systems for Mechanical Applications		07 Hours
Hydraulic and Pneumatic Control Systems: Components, circuit design, and applications. Control Strategies: Introduction to adaptive control, robust control, and predictive control. System Integration: Integrating control systems with mechanical components to create efficient, responsive mechanical systems.		
UNIT – V: Advanced Topics and Emerging Technologies		08 Hours
Regenerative and Energy Efficient Drives: Techniques and importance of energy efficiency in drive systems. Wireless and Remote Control of Drives: Technologies and applications in modern industry. Case Studies and Applications: Real-world applications and case studies focusing on innovative uses of drives and control systems in mechanical engineering.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply theoretical knowledge of different drive systems to evaluate and select suitable mechanisms for specific mechanical engineering applications.	L3
2	Design and analyze power electronic circuits used in drive systems to meet specified performance and efficiency criteria.	L3
3	Implement advanced motor control techniques for various types of electric motors, optimizing for performance and energy efficiency.	L3
4	Integrate diverse control systems, including hydraulic and pneumatic, into comprehensive mechanical system designs.	L4
5	Critically assess and adapt emerging drive technologies and control strategies to innovate and solve real-world mechanical engineering problems.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11		1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

Textbooks:

1. Hughes, A., & Drury, B. (2013). Electric Motors and Drives: Fundamentals, Types, and Applications (4th ed.). Elsevier.
2. Mohan, N., Undeland, T. M., & Robbins, W. P. (2003). Power Electronics: Converters, Applications, and Design (3rd ed.). Wiley.

Reference Books:

1. Sen, P. C. (2014). Principles of Electric Machines and Power Electronics (3rd ed.). Wiley.
2. Dorf, R. C., & Bishop, R. H. (2016). Modern Control Systems (13th ed.). Pearson.

MATERIALS FOR ADDITIVE MANUFACTURING [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code	:	Credits	03
Hours / Week	:	Total Hours	39 Hours
L-T-P-S	:	3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand the role and selection of various materials used in additive manufacturing. 2. Explore design and quality aspects related to additive manufacturing, including intellectual property and commercialization. 3. Study mathematical models and decision methods for optimizing additive manufacturing processes. 4. Investigate the applications of additive manufacturing in biomedical devices and other industries. 5. Learn advanced techniques and advancements in rapid manufacturing for polymeric, metallic, and ceramic objects.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the realworld - and when that's possible, it helps improve the students' understanding.			
UNIT – I : ROLE OF MATERIALS			09 Hours
Choosing Materials for Manufacturing, Multiple Materials, Metal AM Processes & Materials Composite Materials, Biomaterials, Hierarchical Materials & Bio mimetics, Ceramics & Bio-ceramics, Shape-Memory Materials, 4D Printing & Bio-active materials, Discussion on different materials used, multifunctional and graded materials in AM			

UNIT – II: Power Electronics in Drive Systems		06 Hours
Machines for Additive Manufacturing, Secondary Rapid Prototyping processes, Intellectual Property, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing. Design for AM (Build orientation, Topology optimization, Conformal cooling channels).		
UNIT – III: MATHEMATICAL MODELS IN AM		09Hours
Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation. Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Model validation for different criteria). Thermal cycle, Single bead and multi bead formation in cladding based AM processes		
UNIT – IV: ADDITIVE MANUFACTURING FOR BIO MEDICAL DEVICES & OTHERS		09 Hours
Bio microfluidics, Tissue Engineering. 3D Printing in Medicine, Computer Aided Design approach, medical research and clinical grade AM materials and AM fabrication methods Biomedical Applications, Direct Digital Manufacturing, Distributed Manufacturing, Mass Customization, , Aerospace & Automotive Applications, Architectural Engineering, Food & Consumer Applications, Personalized Surgery, Art, Fashion, Jewelry, Toys & Other Applications		
UNIT – V: RAPID MANUFACTURING OBJECTS		06 Hours
RM of polymeric objects, Direct and indirect routes for RM of metallic & ceramic objects, Advancement in RM (Synergistic integration of hybrid processes and multiple technologies). Smart materials.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze the selection and application of various materials used in additive manufacturing, including composites, biomaterials, ceramics, and shape-memory materials.	L3
2	Design additive manufacturing processes considering build orientation, topology optimization, and conformal cooling channels for improved product development and commercialization.	L3
3	Develop mathematical models for additive manufacturing processes to optimize part fabrication time, cost, and defect control.	L3
4	Evaluate the use of additive manufacturing in biomedical devices and other industries, focusing on specific applications and the advantages of AM methods.	L4

5	Implement rapid manufacturing techniques for polymeric, metallic, and ceramic objects, incorporating advancements in hybrid processes and smart materials.												L4	
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbooks:

1. Gibson, I., Rosen, D., & Stucker, B. (2020). Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing. Springer.
2. Zhou, K., & Wang, C. (2021). Additive Manufacturing: Materials, Processes, Quantifications and Applications. Elsevier.

Reference Books:

1. Srivatsan, T. S., & Sudarshan, T. S. (2015). Additive Manufacturing: Innovations, Advances, and Applications. CRC Press.
2. Chua, C. K., & Leong, K. F. (2017). 3D Printing and Additive Manufacturing: Principles and Applications (5th ed.). World Scientific.

AUTOTRONICS			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code :		Credits	: 03
Hours/Week : 03 Hours		Total Hours	:
39Hours			
L-T-P-S :		3-0-0-0	
<u>Course Learning Objectives:</u>			
This course will enable students to:			
1. Understand the significance of autotronics in modern vehicles. 2. Learn the basics of automotive electronics, sensors, and ECUs. 3. Master automotive communication systems and diagnostic protocols. 4. Gain expertise in engine management and advanced driver-assistance systems. 5. Explore hybrid and electric vehicle technologies, and future trends in automotive electronics			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.			
• Lecture method means it includes not only traditional lecture method but different <i>types of teaching methods</i> that may be adopted to develop the course outcomes. • Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. • Show Video/animation films to explain the functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher-order Thinking questions in the class. • Adopt Problem-Based Learning, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding. • Practical experimentation of material testing of different metals and alloys			
Unit-1: Introduction to Autotronics			8 Hours

Overview of Autotronics and its significance in modern vehicles. Basic electronics and electrical systems in automobiles. Sensors and actuators: Types, working principles, and applications. Electronic control units (ECUs): Functionality and architecture.	
Unit-2: Automotive Communication Systems	8 Hours
In-vehicle networking: CAN, LIN, MOST, and FlexRay protocols. Data transmission and communication standards in automobiles. Diagnostics and On-Board Diagnostics (OBD) systems Real-time operating systems and software for automotive applications.	
Unit-3: Engine Management Systems	8 Hours
Electronic Fuel Injection (EFI) systems: Components and operation. Ignition systems: Types, working principles, and control strategies. Exhaust gas recirculation and emission control technologies. Advanced driver-assistance systems (ADAS): Functions and integration.	
Unit-4: Hybrid and Electric Vehicle Technology:	8 Hours
Basics of hybrid and electric powertrains. Battery management systems: Monitoring, control, and safety. Regenerative braking systems and energy recovery. Power electronics in hybrid and electric vehicles: Inverters, converters, and controllers.	
Unit-5: Advanced Topics in Autotronics:	7 Hours
Autonomous vehicles: Sensors, algorithms, and control systems. Vehicle-to-everything (V2X) communication and connectivity. Advanced safety systems: Collision avoidance, adaptive cruise control, and lane-keeping assistance. Future trends in automotive electronics: AI and machine learning in vehicles.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze and evaluate the functionality and architecture of Electronic Control Units (ECUs) within modern automotive systems to optimize vehicle performance.	L3
2	Assess and implement automotive communication protocols such as CAN, LIN, MOST, and FlexRay to enhance in-vehicle networking and diagnostic capabilities.	L3
3	Design and manage advanced engine management systems, including Electronic Fuel Injection (EFI) and ignition control strategies, to improve fuel efficiency and emission control.	L3
4	Develop and integrate hybrid and electric vehicle technologies, focusing on battery management systems, regenerative braking, and power electronics to enhance vehicle sustainability and performance.	L4

5	Investigate and apply advanced topics in autotronics such as autonomous vehicle technologies, V2X communication, and AI-driven safety systems to advance future automotive innovations.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Navet, N., & Simonot-Lion, F. (2017). Automotive Embedded Systems Handbook. CRC Press.
2. Ribbens, W. (2017). Understanding Automotive Electronics. Elsevier.

Reference Books:

1. Reif, K. (2014). Automotive Mechatronics: Automotive Networking, Driving Stability Systems, Electronics. Springer.
2. Mi, C., Masrur, M. A., & Gao, D. W. (2017). Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives. Wiley.

WIND ENERGY SYSTEMS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Comprehend the basic principles of wind energy conversion and the components of wind turbines 2. Optimize blade designs and understand advanced aerodynamic effects on turbine efficiency 3. Understand the dynamic loads and structural behavior of wind turbines 4. Implement control systems to enhance wind turbine performance and grid stability 5. Explore the unique challenges of offshore wind energy systems, including design and maintenance.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding. •	
UNIT – I : FUNDAMENTALS OF WIND ENERGY AND RESOURCE	06 Hours
Overview of wind energy as a renewable resource. Historical development and current trends in wind energy. Basic components and functioning of wind turbines. Wind characteristics: speed, direction, and variability. Methods for measuring and estimating wind resources. Criteria for selecting wind farm sites and optimizing layout.	
UNIT – II: WIND TURBINE AERODYNAMICS AND PERFORMANCE:	08 Hours

Airfoil characteristics and aerodynamic forces, Blade Element Momentum (BEM) theory. Power coefficient and its significance in wind turbine design, 3D aerodynamic effects and tip loss corrections, Dynamic stall and its impact on turbine blade performance. Aerodynamic optimization of wind turbine blades, Standards and processes for turbine performance testing, Power curve measurement and interpretation, Certification procedures and compliance requirements.

UNIT - III: STRUCTURAL DYNAMICS AND DESIGN OF WIND TURBINES	07 Hours

Load analysis: aerodynamic, gravitational, and inertial forces, Natural frequencies, mode shapes, and resonance in turbine structures, Dynamic response and vibration analysis of turbine components,

Fatigue life prediction and load spectrum analysis, Structural health monitoring systems and strategies, Design for reliability and mitigation of fatigue-induced failures, Material properties and selection criteria for wind turbine components.

UNIT - IV: ELECTRICAL POWER CONVERSION AND GRID INTEGRATION	09 Hours

Types of wind turbine generators and power electronics, Power conversion and transmission systems in wind turbines, Challenges and strategies for integrating wind power into electrical grids, Role of energy storage in wind energy systems, Types of energy storage technologies: batteries, flywheels, pumped hydro, Hybrid systems combining wind power with other renewable sources.

UNIT - V: OFFSHORE WIND ENERGY AND FUTURE TRENDS	06 Hours

Design and deployment challenges unique to offshore wind, Structural design of offshore wind turbines and floating platforms, Installation, operation, and maintenance of offshore wind farms, Recent advancements in wind turbine technology and materials. Emerging technologies: floating turbines, airborne wind energy, bladeless turbines, Future trends and potential developments in wind energy research and deployment.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Assess and interpret wind resource data to determine optimal sites for wind farm development	L3
2	Analyze the aerodynamic forces acting on wind turbine blades using the Blade Element Momentum (BEM) theory. Optimize blade designs for enhanced efficiency through advanced aerodynamic principles.	L3
3	Design wind turbine components considering material properties, structural integrity, and fatigue life	L3
4	Develop and simulate control algorithms to optimize the performance and stability of wind turbines. Analyze the electrical power conversion processes and solve challenges related to grid integration of wind power.	L4
5	Evaluate the unique design, deployment, and maintenance challenges associated with offshore wind energy systems.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbook:

1. Sørensen, J. D., & Sørensen, J. N. (2010). Wind Energy Systems. Woodhead Publishing.

Reference Books:

1. Centre for Wind Energy Technology (C-WET). Wind Energy Resources Survey in India. [No further details on publisher or publication year available for an accurate APA citation.]
2. Kaldellis, J. K. (2010). Stand-alone and Hybrid Wind Energy Systems. CRC Press.

E-Resources:

1. https://archive.nptel.ac.in/content/storage2/courses/108108078/pdf/chap6/teach_slides06.pdf
2. <https://archive.nptel.ac.in/courses/103/103/103103206/>

MEMS (MICRO ELECTRO MECHANICAL SYSTEMS) [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Introduce the fundamentals, design, and applications of MEMS technology. 2. Understand the properties and uses of various substrate materials and wafers in MEMS. 3. Learn the different fabrication processes used in MEMS manufacturing. 4. Explore the principles and applications of various types of micro sensors. 5. Study the design and functioning of microactuators and their systems.	
<u>Teaching-Learning Process (General Instructions)</u> These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction to MEMS	06 Hours
Definition – development- fundamentals of MEMS. Micro fluidics, microelectronics, micro systems- design and fabrication, working principles and applications. Integrated circuit processes, potential of MEMS in industry	
UNIT – II: Substrates and Wafers	08 Hours
Materials substrates and wafers, silicon substrate- properties of silicon, silicon compounds, silicon piezo resistors. Gallium Arsenide, quartz, polymer for MEMS, conductive polymer. Shape memory alloys.	
UNIT – III: Fabrication Processes	07 Hours

Photolithography, photo resist applications, light sources, X-ray lithography, electron beam lithography, ion implantation, thin film deposition, diffusion process, Chemical and physical vapour deposition, bulk and surface machining, LIGA, laser ablation process. Micro steriolithography for 3D fabrication and nanolithography.

UNIT – IV: Sensors		06 Hours
Micro sensors, classification of physical sensors, integrated, intelligent or smart sensors, sensors principle, thermal sensors, electrical sensors, mechanical sensors, chemical and biosensors.		
UNIT – V: Microactuators		09 Hours
Electromagnetic and thermal microactuation, mechanical design of micro actuators, microactuator, micro valves, micro pumps, micro motors. Microactuator systems: Ink jet printers, micro-mirror TV projectors. Micro-opto- electromechanical systems, metal oxide semiconductor field effect transistor, multi-disciplinary applications.		

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Analyze the fundamentals, design, and fabrication processes of MEMS and their applications in various industries.	L3												
2	Evaluate the properties and applications of different substrate materials and wafers used in MEMS, including silicon and shape memory alloys.	L3												
3	Apply various MEMS fabrication processes such as photolithography, ion implantation, and thin film deposition to create microsystems.	L3												
4	Classify and assess the principles and applications of different types of micro sensors, including thermal, electrical, mechanical, chemical, and biosensors.	L4												
5	Design and implement microactuator systems for various applications, including electromagnetic and thermal microactuation, micro valves, micro pumps, and micro motors.	L4												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	2	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Senturia, S. D. (2000). Microsystem Design. Kluwer Academic Publishers.
2. Liu, C. (2011). Foundations of MEMS. Prentice Hall.

Reference Books:

1. Maluf, N., & Williams, K. (2004). Introduction to Microelectromechanical Systems Engineering (2nd ed.). Artech House.
2. Korvink, J. G., & Paul, O. (2005). MEMS: A Practical Guide of Design, Analysis, and Applications. Springer.

Professional Elective-III

Robot Kinematics and Dynamics [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L–T–P–S	: 3–0–0–0		
Course Learning Objectives: This Course will enable students to: 1. Deepen understanding of coordinate systems, transformations, and frame representations specifically applied to robotic systems. 2. Develop proficiency in analyzing and solving both forward and inverse kinematics problems for various types of robotic manipulators. 3. Enhance skills in calculating and interpreting differential motions and velocities in robotic systems to optimize operational efficiency. 4. Master dynamic modeling techniques, including Newton-Euler and Lagrangian methods, to accurately predict forces and motions in robotic mechanisms. 5. Explore advanced topics and current research trends in robot kinematics and dynamics to prepare for innovative problem-solving in robotics engineering.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Introduction to Robotic Systems			09 Hours
Overview of Robotics: Types of robots and their applications. Coordinate Systems and Transformations: Frame representations, homogeneous coordinates, and transformation matrices specific to robotic applications. Review of Basic Kinematics and Dynamics: A brief recap			

emphasizing aspects uniquely applicable to robotic systems.

UNIT – II: Forward and Inverse Kinematics of Robots

09 Hours

Forward Kinematics: Derivation of position and orientation for robotic manipulators. Inverse Kinematics: Solution techniques for position and orientation determination of the end-effector. Workspace Analysis: Determination of reachable spaces and dexterous workspaces in robotic systems. Jacobian and Singularities: Understanding the role of the Jacobian matrix in velocity and force analysis, and identifying singular configurations.

UNIT – III: Differential Motions and Velocities

**06
Hours**

Differential Relationships: Mapping from joint velocities to end-effector velocities. Motion Trajectories: Planning and analysis of trajectories in joint space and Cartesian space for robots. Velocity Kinematics: Analysis of velocities within the context of robot manipulators and the implications of different configurations.

UNIT – IV: Robot Dynamics

**07
Hours**

Dynamic Modeling and Equation Derivation: Application of Newton-Euler and Lagrangian methods to robotic systems. Forces and Torques: Computation for static and dynamic cases in robotic arms. Energy Methods in Robotics: Application of energy conservation principles to the analysis and simulation of robotic motion.

UNIT – V: Advanced Topics in Robot Kinematics and Dynamics

**08
Hours**

Multi-body Dynamics: Analysis of complex robotic systems with multiple interconnected bodies. Nonlinear Dynamics of Robots: Study of behavior under non-linear conditions and impacts. Introduction to Computational Dynamics: Use of software tools for simulation and analysis of robotic kinematics and dynamics. Current Trends and Research in Robotic Kinematics and Dynamics: Discussion of recent advancements and future directions in the field.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply transformation matrices and coordinate system techniques to model complex robotic systems and solve spatial relationship problems.	L2 & L3
2	Design and execute kinematic analyses to determine the position, orientation, and trajectory of robot manipulators in both forward and inverse configurations.	L2 & L3
3	Utilize differential kinematics and dynamics to analyze and optimize the velocity and acceleration profiles of robotic systems during operation.	L3

4	Construct dynamic models of robots using advanced mathematical methods and validate these models through computational simulations to predict real-world behavior.	L4
5	Critically assess and integrate current research and technological advances in robot kinematics and dynamics into practical applications and academic discussions.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2009). Robotics: Modelling, Planning and Control. Springer.
2. Craig, J. J. (2017). Introduction to Robotics: Mechanics and Control (4th ed.). Pearson.

Reference Books:

1. Spong, M. W., & Vidyasagar, M. (2008). Robot Dynamics and Control (2nd ed.). Wiley.
2. Angeles, J. (2014). Fundamentals of Robotic Mechanical Systems: Theory, Methods, and Algorithms (4th ed.). Springer.

PROCESSING OF PLASTICS AND COMPOSITES [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VI			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L–T–P–S	: 3–0–0–0		
Course Learning Objectives: This Course will enable students to: 1. Understand the properties, classifications, and applications of various plastics and composite materials. 2. Learn and apply different processing techniques for manufacturing plastic products, focusing on process parameters and quality. 3. Explore and implement various composite processing techniques, ensuring process optimization and quality control. 4. Investigate advanced processing methods, including additive manufacturing and hybrid techniques, for plastics and composites. 5. Conduct mechanical and non-destructive testing, thermal analysis, and quality control procedures for plastics and composites, adhering to industry standards.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Introduction to Plastics and Composites			07 Hours
Overview of plastics and composites, Classification and types of plastics, Types of composite materials, Basic properties and applications, Advantages and limitations			
UNIT – II: Processing Techniques for Plastics			07 Hours

Injection molding, Extrusion, Blow molding, Thermoforming, Rotational molding, Process parameters and their effects on product quality	
UNIT – III: Processing Techniques for Composites	08 Hours
Hand lay-up and spray-up, Filament winding, Pultrusion, Resin transfer molding (RTM), Compression molding, Autoclave and out-of-autoclave processing, Process parameters and quality control	
UNIT – IV: Advanced Processing Methods	09 Hours
Additive manufacturing for plastics and composites, Advanced injection molding techniques, Vacuum-assisted resin infusion, Automated fiber placement (AFP) and automated tape laying (ATL), Hybrid processing techniques, Nano-composites processing	
UNIT – V: Testing and Quality Control	08 Hours
Mechanical testing of plastics and composites, Non-destructive testing methods, Thermal analysis and characterization techniques, Quality control in manufacturing processes, Standards and specifications for plastics and composites, Case studies on quality control and failure analysis	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze the properties and applications of various plastics and composite materials.	L3
2	Apply different processing techniques for manufacturing plastic products, considering process parameters and product quality.	L3
3	Implement various composite processing techniques, ensuring quality control and understanding process parameters.	L3
4	Explore advanced processing methods for plastics and composites, including additive manufacturing and hybrid techniques.	L4
5	Conduct testing and quality control procedures for plastics and composites, utilizing appropriate standards and specifications.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Crawford, R. J., & Throne, J. L. (2012). Plastics Engineering (3rd ed.). Butterworth-Heinemann.
2. Chawla, K. K. (2012). Composite Materials: Science and Engineering (3rd ed.). Springer.

Reference Books:

1. Muccio, E. A. (1994). Understanding Plastics Engineering and Manufacturing: A Practical Guide. Hanser Gardner Publications.
2. Gibson, R. F. (2016). Principles of Composite Material Mechanics (4th ed.). CRC Press.

AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code	:	Credits	: 03
Hours/Week	: 03 Hours	Total Hours	:
39Hours			
L-T-P-S	:	3-0-0-0	
Course Learning Objectives: This course will enable students to: 1. Introduce the fundamental concepts and functions of automotive chassis systems. 2. Explain the design and operational principles of various suspension systems. 3. Describe the mechanics and components of different steering systems. 4. Provide an understanding of drivetrain and transmission system layouts and functions. 5. Explore advanced technologies in differentials and their impact on vehicle performance.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method but different <i>types of teaching methods</i> that may be adopted to develop the course outcomes. Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. Show Video/animation films to explain the functioning of various concepts. Encourage Collaborative (Group Learning) Learning in the class. To make Critical thinking , ask at least three Higher-order Thinking questions in the class. Adopt Problem-Based Learning , which fosters students’ Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student’s understanding.			
Unit-1: Introduction to Automotive Chassis Systems			8 Hours

Overview of Automotive Chassis: Definition and functions, Types of chassis layouts (body-on-frame, monocoque). Materials Used in Chassis Construction: Types of materials (steel, aluminum, composites), Material properties and selection criteria. Design Considerations: Load distribution and structural integrity, Safety regulations and standards. Chassis Components: Frame, subframe, and cross members, Design and manufacturing processes		
Unit-2: Suspension Systems		7 Hours
Introduction to Suspension Systems: Purpose and function of suspension, Types of suspension systems (dependent, independent). Suspension Geometry: Camber, caster, toe, and their effects on vehicle dynamics, Suspension kinematics Suspension Components: Springs (coil, leaf, torsion bar), Dampers (shock absorbers, struts), Anti-roll bars and bushings. Advanced Suspension Technologies: Active and semi-active suspension systems, Air suspension and electronic control systems		
Unit-3: Steering Systems		7 Hours
Fundamentals of Steering Systems: Types of steering mechanisms (manual, power-assisted), Rack and pinion, recirculating ball, and worm gear steering. Steering Geometry and Alignment: Ackermann principle, Understeer and oversteer, Wheel alignment (toe, camber, caster). Steering System Components: Steering wheel, column, and rack, Power steering pumps and hoses, Sensors and electronic control units (ECUs). Modern Steering Technologies: Electric power steering (EPS), Four-wheel steering, Steer-by-wire systems		
Unit-4: Drivetrain and Transmission Systems		8 Hours
Overview of Drivetrain Systems: Layouts (FWD, RWD, AWD, 4WD), Function and importance of drivetrain components. Clutches and Torque Converters: Types of clutches (single plate, multi-plate, centrifugal), Torque converter operation and components. Manual Transmission Systems: Gearbox design and operation, Synchronizers and shift mechanisms, Types of manual transmissions (synchromesh, constant mesh). Automatic Transmission Systems: Types of automatic transmissions (traditional, CVT, DCT), Hydraulic systems and electronic control units, Transmission fluid and cooling		
Unit-5: Final Drive and Differential Systems		9 Hours
Introduction to Final Drive: Purpose and function of the final drive, Types of final drive systems (front, rear, all-wheel drive). Differential Systems: Open, limited-slip, and locking differentials, Planetary gear sets and operation. Axles and Driveshafts: Design and construction of axles, Driveshaft components and balancing. Advanced Differential Technologies: Electronic limited-slip differentials (eLSD), Torque vectoring systems, Impact of differentials on handling and performance.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		

1	Apply principles of chassis design to evaluate and improve vehicle structural integrity and safety.	L3
2	Analyze suspension system components and geometries to enhance vehicle ride comfort and handling performance.	L3
3	Design and troubleshoot various steering systems to ensure optimal vehicle steering response and control.	L3
4	Implement and optimize drivetrain and transmission systems to achieve desired vehicle performance and efficiency.	L4
5	Integrate advanced differential technologies to improve vehicle traction and stability under various driving conditions.	L4

**Table: Mapping Levels of COs to POs /
PSOs**

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Birch, T. W. (2019). Automotive Chassis Systems (6th ed.). Pearson.
2. Gillespie, T. D. (1992). Fundamentals of Vehicle Dynamics. SAE International.

Reference Books:

1. Naunheimer, H., et al. (2010). Automotive Transmissions: Fundamentals, Selection, Design and Application (2nd ed.). Springer.
2. Adams, H. (1992). Chassis Engineering: Chassis Design, Building & Tuning for High Performance Handling. HP Books.

HYDROGEN ENERGY AND STORAGE [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Describe historical developments and current advancements in hydrogen technologies. Identify the unique properties of hydrogen relevant to its use as a fuel. 2. Analyze various production methods such as steam methane reforming, electrolysis, and biomass conversion 3. Identify key components of hydrogen distribution systems, including pipelines and refueling stations. 4. Describe the working principles and components of various types of fuel cells 5. Conduct life cycle assessments to evaluate the environmental footprint of hydrogen production, storage, and utilization.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I: OVERVIEW OF HYDROGEN ENERGY:	06 Hours
History and development of hydrogen technologies, Hydrogen as an energy carrier in modern energy systems, Global energy challenges and the role of hydrogen, Physical and chemical properties of hydrogen, Hydrogen's advantages and challenges as a fuel, Safety considerations in handling hydrogen,	
UNIT – II: HYDROGEN PRODUCTION TECHNOLOGIES:	08 Hours
Conventional Hydrogen Production, Steam Methane Reforming (SMR) and Partial Oxidation. Coal Gasification and other fossil fuel-based methods, Water Electrolysis (Alkaline, PEM, SOEC).	

Biological and Photolytic production processes, Thermochemical cycles, Novel methods and future trends in hydrogen production, Hydrogen production from biomass and waste materials.

UNIT – III: HYDROGEN STORAGE AND DISTRIBUTION		09 Hours
Compressed Gas and Liquid Hydrogen Storage, Cryo-compressed hydrogen storage, Solid-state storage (Metal Hydrides, Chemical Hydrides), Carbon-based storage materials and other novel methods, Material considerations and safety in hydrogen storage. Hydrogen distribution systems: Pipelines, trucking, and shipping, Infrastructure requirements for hydrogen refueling stations, Technological challenges and solutions in hydrogen logistics, Economic feasibility and scalability of hydrogen distribution networks		
UNIT – IV : FUEL CELL TECHNOLOGIES AND APPLICATIONS		07 Hours
Fundamentals of fuel cells: PEMFC, SOFC, MCFC, etc, Components and operation of fuel cells. Applications of fuel cells in transport, stationary power, and portable devices, Efficiency analysis and comparison with conventional energy systems.		
UNIT – V		06 Hours
Evaluate the financial viability and market potential of hydrogen technologies, including production, storage, and distribution, using economic modeling and cost-benefit analysis frameworks		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze the significance of hydrogen as an energy carrier in the context of global energy demands. Formulate safety protocols and strategies for handling hydrogen based on its properties.	L3
2	Evaluate and justify the selection of hydrogen production methods based on efficiency, environmental impact, and scalability	L3
3	Analyze and compare the various hydrogen storage technologies, including compressed gas, liquid hydrogen, cryo-compressed hydrogen, solid-state storage (metal hydrides and chemical hydrides), and carbon-based storage materials.	L3
4	Evaluate and differentiate the operational principles and characteristics of different types of fuel cells, including Proton Exchange Membrane Fuel Cells (PEMFC), Solid Oxide Fuel Cells (SOFC), and Molten Carbonate Fuel Cells (MCFC). Assess the economic viability and lifecycle costs of deploying fuel cell technologies across different applications compared to traditional energy solutions	L4
5	Evaluate the financial viability and market potential of hydrogen technologies, including production, storage, and distribution, using economic modeling and cost-benefit analysis frameworks also Assess the environmental impacts of hydrogen energy systems through life cycle assessments (LCA), focusing on their carbon footprint and resource utilization	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

TEXT BOOKS:

1. Bent Sørensen and Giuseppe Spazzafumo (2018), Hydrogen and Fuel Cells, Woodhead Publishing, Elsevier Science
2. Paul Ekins(2010), Hydrogen Energy, Earthscan

REFERENCE BOOKS:

1. Detlev Stolten (2011), Hydrogen and Fuel Cells. Fundamentals, Technologies and Applications, Wiley, John & Sons

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc22_ch66/preview
2. <https://nptel.ac.in/courses/103101215>

TOTAL QUALITY MANAGEMENT			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject code	Credits	:	03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-S	:	3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. To understand the fundamental principles and concepts of Total Quality Management (TQM) and their application in improving organizational performance. 2. To gain proficiency in the use of statistical tools and techniques for quality control and improvement. 3. To develop the ability to analyze and evaluate quality management systems and identify opportunities for continuous improvement. 4. To learn how to design and implement quality plans that align with customer expectations and organizational goals. 5. To acquire knowledge of international quality standards and frameworks, and how to apply them to achieve certification and enhance quality assurance processes.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Introduction to Quality Management			06 Hours
Concepts of Quality: Definitions and dimensions of quality, Evolution of quality management, Quality gurus: Deming, Juran, Crosby, Feigenbaum. Principles of Total Quality Management (TQM): Customer focus, Continuous improvement (Kaizen),			

Employee involvement and empowerment. TQM Framework: TQM models: Deming's 14 points, Juran's Trilogy, Crosby's Quality Management Maturity Grid

UNIT – II: Quality Planning and Control		07 ours
Quality Planning : Quality policy and objectives, Strategic quality planning, Quality function deployment (QFD) .Quality Control Tools: Statistical process control (SPC), Control charts for variables and attributes, Process capability analysis. Quality Improvement Techniques: PDCA cycle (Plan-Do-Check-Act), Six Sigma methodology, Lean principles and waste reduction.		
UNIT – III: Quality Assurance and Standards		08 Hours
Quality Assurance (QA): Concepts and importance of QA, QA in design and development, QA in manufacturing and services. Quality Management Systems (QMS): ISO 9001 standards, Implementation and certification process, Auditing and documentation. Advanced Quality Management Standards: ISO 14000 (Environmental Management), ISO 45000 (Occupational Health and Safety), ISO/TS 16949 (Automotive Quality Management).		
UNIT – IV : Tools and Techniques for Quality Improvement		07 Hours
Problem Solving and Decision Making: Root cause analysis, Failure mode and effects analysis (FMEA), Design of experiments (DOE). Quality Improvement Tools: Pareto analysis, Fishbone diagram (Ishikawa), Flowcharts and process mapping. Benchmarking and Best Practices: Types of benchmarking, Steps in benchmarking process, Case studies of successful quality improvement		
UNIT – V: Quality Management in Practice		06 Hours
Quality in Manufacturing: Total productive maintenance (TPM), Just-in-time (JIT) and Kanban systems, Statistical quality control (SQC). Quality in Services: Service quality dimensions (SERVQUAL), Quality in healthcare, education, and hospitality, Customer satisfaction and feedback mechanisms. Future Trends in Quality Management: Quality 4.0 and digital transformation, Role of big data and analytics in quality, Sustainable quality management practices.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply statistical process control (SPC) techniques to monitor and control manufacturing processes, ensuring product quality and consistency.	L3
2	Analyze quality management systems (QMS) to identify areas for improvement and develop strategies for enhancing overall system performance.	L3
3	Evaluate various quality improvement methodologies such as Six Sigma and Lean principles to determine their	L3

	effectiveness in different industrial contexts.	
4	Design comprehensive quality plans that integrate quality function deployment (QFD) and other planning tools to meet customer requirements and organizational goals.	L4
5	Implement advanced quality assurance protocols and standards, including ISO 9001, to achieve and maintain certification and continuous quality improvement in manufacturing and service processes.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Besterfield, D. H. (2018). Total Quality Management (5th ed.). Pearson.
2. Goetsch, D. L., & Davis, S. (2016). Quality Management for Organizational Excellence: Introduction to Total Quality (8th ed.). Pearson.

Reference Books:

1. Evans, J. R., & Lindsay, W. M. (2014). The Management and Control of Quality (8th ed.). Cengage Learning.
2. Juran, J. M. (2010). Juran's Quality Handbook (6th ed.). McGraw-Hill Education.

FUNDAMENTALS OF ECONOMICS [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Realize importance of Fundamentals of economics in Engineering. 2. Comprehend the ideas of Time value of money and Inflation. 3. Explain Present worth and equivalent annual worth calculations 4. Demonstrate Economic planning and finance commission and its importance 5. Recognize the importance of taxation, RBI and its monetary operations and public finance	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours

Introduction to Engineering economics, Engineering decision makers, engineering and economics, problem solving and decision making, strategy and tactics, factors of production, Production possibility schedule and curve, marginal rate of transformation, Concept of economic growth. (Text Book-1: Chapter 1: 1.1 to 1.4, Chapter 2: 2.1 to 2.4)	
UNIT – II	08 Hours
Time value of money - Simple interest, compound interest – nominal interest rate, effective interest rate, and inflation. (Text Book-1: Chapter 2: 2.1-2.7).	
UNIT – III	07 Hours
.Present worth calculations, Equivalent Annual worth Comparison methods, Situations for Equivalent Annual worth Comparison, Consideration of asset life, comparison of assets with equal and unequal lives. (Text Book-1: Chapter 3: 3.1 to 3.5)	
UNIT – IV	08 Hours
Economic Planning- Regional planning, National planning and Inclusive development. Planning in India- Vishveshwaraiah Plan, Bombay Plan, Gandhian Plan, Harrod Domar plan, Main objectives of Planning, Relevance of Planning in Economic reforms of the Nation, Five year plans, Finance commission and its functions (Text Book-2: Chapter 4: 4.4 to 4.6, Chapter- 5: 5.2,5.5, to 5.7, 5.19- 5.27, 5.33, 5.38,)	
UNIT – V	08 Hours
The idea of National income- GDP, GNP, NDP and NNP, Types of economic sectors- primary, secondary and tertiary, Reserve Bank of India and its Monetary operations, Tax structure in India and GST, Public Finance in India- Budgetary terms (Text Book-2: Chapter 1: 1.13, 1.14- 1.17, Chapter 12: 12.4- 12.8, Chapter 17: 17.3-17.4, 17.7)	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the principles of engineering economics to make informed engineering decisions, considering both economic and technical factors.	L3
2	Analyze the impact of time value of money on engineering projects, calculating present and future values using simple and compound interest, nominal and effective interest rates, and accounting for inflation.	L3
3	Evaluate various economic alternatives using present worth and equivalent annual worth comparison methods, taking into account asset life and the comparison of assets with equal and unequal lives.	L3
4	Design economic plans at regional and national levels by understanding and applying different planning strategies, such as the Vishveshwaraiah Plan, Bombay Plan, Gandhian Plan, and Harrod Domar plan, and by evaluating the relevance of these plans in the	L4

	context of economic reforms.	
5	Implement knowledge of national income concepts (GDP, GNP, NDP, and NNP) and the structure of economic sectors to assess the economic environment, understand the role of the Reserve Bank of India, analyze the tax structure and GST, and interpret budgetary terms in the context of public finance in India.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	3	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. Riggs, J., Bedworth D., & Randhawa S., (2011), **Engineering Economics**, 4th Edition, McGraw-Hill Education.
2. Ramesh Singh., (2023-24), Indian Economy, 15th Edition, McGraw- Hill Publications

REFERENCE BOOKS:

1. Panneerselvam R, (2013), **Engineering Economics**, 2nd edition, Prentice Hall India Learning Private Limited

INSTRUMENTATION AND CONTROL [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 04 Hours	Total Hours : 26+26Hours
L-T-P-S : 2-0-2-0	
Course Learning Objectives: This course provides an introduction to the fundamental concepts of instrumentation and control engineering. It is designed for undergraduate students and covers essential topics in instrumentation and basic control systems, ensuring students gain foundational knowledge. 1. Explain the operating principles of various measurement systems and how they apply to engineering problems. 2. Describe the fundamental roles of sensors, transducers, and signal conditioning in instrumentation systems 3. Illustrate the basic structure and function of control systems through examples and mathematical models. 4. Evaluate control system performance using time-domain and frequency-domain analysis techniques. 5. Apply control theories and methods to design simple control systems for practical engineering applications.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. - Show Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, ask at least three Higher order Thinking questions in the class. - Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it. - Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every concept can be applied to the real world - and when that's possible, it helps improv the students' understanding.	
UNIT – I Introduction to Instrumentation	09 Hours
Introduction to Instrumentation, Overview of instrumentation in engineering. Importance and applications in various systems. SI units and standards in measurement. Importance of accuracy and calibration	

UNIT – II: Basic Components of Instrumentation		09 ours
Sensors and Transducers Types and working principles of sensors (e.g., temperature, pressure, force. Applications in different engineering fields. Signal processing: filters, amplifiers, and converters. Importance of noise reduction and data accuracy.		
UNIT – III: Introduction to Control Systems		08 Hours
Basics of Control Systems, Introduction to open-loop and closed-loop control systems. Examples in engineering (e.g., temperature, speed control). Mathematical Modelling of Control Systems Transfer functions and block diagrams. Modelling of engineering systems (e.g., mass-spring-damper, fluid systems).		
UNIT – IV: Analysis of Control Systems		08 Hours
Frequency-Domain Analysis Frequency response analysis using Bode plots. Interpretation of frequency response characteristics. Time-Domain Analysis of transient and steady-state responses. Time-domain specifications (rise time, settling time, overshoot).		
UNIT – V: Basic Design of Control Systems		06 Hours
PID Controllers Application of Proportional, Integral, and Derivative controllers. Tuning methods and practical considerations. Stability and Performance Stability analysis using root locus and other techniques. Design for stability and performance in control applications Case studies in various engineering systems (e.g., vibration control, thermal systems).		

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Apply the principles of instrumentation to select and utilize appropriate sensors and transducers for measuring physical quantities (e.g., temperature, pressure, force) in diverse engineering applications.	L1												
2	Analyze signal processing components, such as filters, amplifiers, and converters, to enhance noise reduction and data accuracy in measurement systems.	L2												
3	Evaluate the performance of control systems by constructing and interpreting mathematical models using transfer functions and block diagrams, and differentiating between open-loop and closed-loop systems.	L3												
4	Design control systems by conducting frequency-domain and time-domain analysis, utilizing techniques like Bode plots and transient response analysis to meet specific performance criteria (e.g., rise time, settling time, overshoot).	L2												
5	Implement and tune PID controllers in practical engineering scenarios, employing stability analysis methods such as root locus to ensure optimal control system performance and stability in applications like vibration control and thermal systems.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	2	3	1	1	1	2	2	1	1	3	3

C02	3	3	3	2	3	1	1	1	2	2	1	1	3	3
C03	3	3	3	2	3	1	1	1	2	2	1	1	3	3
C04	3	3	3	2	3	1	1	1	2	2	1	1	3	3
C05	3	3	3	2	3	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Nakra, B. C., & Chaudhary, K. K. (2003). Instrumentation, Measurement and Analysis (3rd ed.). McGraw-Hill Education.
2. Nagrath, I. J., & Gopal, M. (2009). Control Systems Engineering (5th ed.). New Age International Publishers. ISBN: 9788122420080.

Reference Books:

1. Ogata, K. (2009). Modern Control Engineering (5th ed.). Prentice Hall.
2. Doebelin, E. O. (2004). Measurement Systems: Application and Design (5th ed.). McGraw-Hill Education.

OPEN ELECTIVE-2

AUTOMOBILE ENGINEERING	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand the basic principles of automobile engineering, including vehicle dynamics, propulsion systems, and the integration of mechanical components. 2. Develop a comprehensive understanding of electric vehicles, including their architecture, key components, and the underlying electrical systems. 3. Acquire knowledge of hybrid technologies and advanced propulsion systems, focusing on their design, functionality, and environmental impact. 4. Gain insights into advanced driver-assistance systems (ADAS), exploring their technological foundations, operational mechanisms, and benefits. 5. Explore the design considerations, safety standards, and regulatory requirements applicable to modern automobiles, particularly electric and hybrid vehicles.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Fundamentals of Automobile Engineering	06 Hours
Overview of Automobile Systems: Introduction to the various systems in automobiles such as chassis, transmission, engine, braking, and steering systems. Automotive Materials and Manufacturing Processes: Study of materials used in automotive manufacturing, including emerging materials for lightweight construction.	
UNIT – II: Electric Vehicles (EVs)	10 Hours

Introduction to Electric Vehicles: History and evolution of EVs, comparison with internal combustion engine vehicles. EV Architecture and Systems: Detailed study of electric vehicle components including batteries, electric motors, controllers, and regenerative braking systems. Battery Technology and Management Systems: Types of batteries used in EVs, battery management systems, charging technologies, and strategies for enhancing battery life.

UNIT – III: Hybrid and Advanced Propulsion Systems

10 Hours

Hybrid Vehicle Technologies: Overview of hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and their drivetrain configurations. Advanced Propulsion Technologies: Fuel cell vehicles (FCVs), solar-powered vehicles, and alternative fuels. Thermal Management in EVs and HEVs: Heat generation and cooling requirements, strategies for managing thermal loads in electric and hybrid vehicles.

UNIT – IV: Advanced Driver-Assistance Systems (ADAS)

07 Hours

Fundamentals of ADAS: Introduction to ADAS and its role in improving safety and driving comfort. Key ADAS Technologies: Sensors and actuators used in ADAS such as cameras, radar, LIDAR, ultrasonic sensors, and their integration into vehicle systems. ADAS Features: Detailed study of features such as adaptive cruise control, lane keeping assist, automatic parking, and collision avoidance systems.

UNIT – V: Design and Safety Considerations

08 Hours

Vehicle Design for Safety: Design principles for occupant safety, pedestrian safety, and crashworthiness. Regulatory and Testing Standards: Overview of global safety standards, emissions regulations for EVs and HEVs, and testing protocols. Future Trends and Innovations: Autonomous vehicles, vehicle connectivity (V2X), and emerging trends in vehicle design and safety.

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Analyze and evaluate the mechanical and dynamic aspects of automobile systems, applying principles of vehicle dynamics and automotive safety.	L3												
2	Design and assess electric vehicle systems, including battery management and electric propulsion, to optimize performance and efficiency.	L3												
3	Implement hybrid and alternative propulsion technologies in vehicle design, considering environmental and efficiency metrics.	L3												
4	Integrate advanced driver-assistance systems into automotive designs, enhancing vehicle safety and driving experience through technological innovations.	L4												
5	Navigate the regulatory landscape for automobile design and safety, applying standards and protocols to ensure compliance and innovation in vehicle development.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3

C04	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbooks:

1. Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. (2018). Modern Electric, Hybrid Electric, and Fuel Cell Vehicles (3rd ed.). CRC Press.
2. Erjavec, J., & Thompson, R. (2014). Automotive Technology: A Systems Approach (6th ed.). Cengage Learning.

Reference Books:

1. Denton, T. (2016). Advanced Automotive Fault Diagnosis: Automotive Technology: Vehicle Maintenance and Repair (4th ed.). Routledge.
2. Husain, I. (2011). Electric and Hybrid Vehicles: Design Fundamentals (2nd ed.). CRC Press.

TOTAL QUALITY MANAGEMENT AND RELIABILITY [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: - Understand the evolution and importance of quality control and learn the fundamental principles of Total Quality Management (TQM). - Master the application of quality improvement tools such as Kaizen, Six Sigma, and quality circles to enhance organizational processes. - Gain proficiency in establishing and maintaining Quality Management Systems, including familiarity with ISO 9000 and ISO 14000 standards. - Develop skills in assessing and improving product reliability through quantitative measures and reliability engineering techniques. - Learn to perform risk assessments and design for reliability, incorporating redundancy and robustness into product designs.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. - Show Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, ask at least three Higher order Thinking questions in the class. - Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it. - Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every concept can be applied to the real world - and when that's possible, it helps improv the students' understanding.	
UNIT – I Quality Control	09 Hours
Quality Control Management of product quality, evolution of quality control, changing quality concepts, modern concept of total quality management, contribution of quality masters (Deming, Juran, Crosby, Ishikawa, Taguchi), process control charts; statistical quality control tools; statistical process control and process capability. (CHAPTER -1)	

UNIT – II: Total Quality Management	09 Hours
Total quality management , concept of total quality, total quality maintenance, total quality in service sector; role of customer and people in total quality management; steps for quality improvement, Kaizen; organizing for effective quality management; creating quality by design assessment of customer's needs; formulation of design specifications; standardization; costs of quality; quality circles; 5-S concept; zero defect program; Six- Sigma approach.(CHAPTER-2,3)	
UNIT – III: Quality Management Systems	08 Hours
Quality Management Systems: ISO 9000 series of standard; ISO 14000 series of standards, Strategic tools and techniques for TQM, need for tools and techniques in TQM; commonly used tools for TQM; approaches and deployment of tools for quality planning – quality function deployment (QFD), concurrent engineering; tools for continuous improvement -Deming's Plan – Do – Check – Act (PDCA) cycle, Poka – Yoke (Mistake – Proofing), Taguchi's quality loss function.(CHAPTER 4)	
UNIT – IV: Reliability	06 Hours
Reliability , concept and definition, reliability parameters: Reliability as a function of time, failure rate as a function of time, constant failure rate, mean time to failure (MTTF), MTTF as a function of failure rate, mean time between failure (MTBF), mean down time (MDT), maintainability & availability, increasing failure rate, bath-tub curve; Weibull distribution, System reliability models: series system, parallel system, series-parallel system, six sigma approach in reliability.(CHAPTER 1)	
UNIT – V: Risk Assessment & Reliability in Design	07 Hours
Risk assessment & reliability design , causes of failures, failure modes & effects analysis (FMEA), faulty tree analysis (FTA); Tribological failure and monitoring techniques; Design based on reliability, redundancy in design.(CHAPTER 2,3)	

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Implement and manage quality control systems, utilizing concepts from TQM and contributions of quality masters to enhance product and service quality.	L1												
2	Apply Six Sigma methodologies and other quality tools to systematically improve processes and reduce defects in manufacturing and service sectors.	L2												
3	Integrate ISO standards and strategic TQM tools like QFD and Poka-Yoke to ensure consistent quality and meet customer satisfaction.	L3												
4	Analyze and improve system reliability using statistical methods, reliability modeling, and Weibull distribution to predict and enhance product lifespan.	L2												
5	Conduct comprehensive risk assessments and reliability analysis in design, employing techniques like FMEA and FTA to anticipate and mitigate potential failures.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3

C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbook:

1. Lal, H. (2015). Total Quality Management – A Practical Approach. New Age International (P) Ltd. Publishers.
2. Mondal, S. K. (2009). Total Quality Management Principles and Practice. Vikas Publishing House Pvt. Ltd.

Reference Books:

1. Feigenbaum, A. V. (1991). Total Quality Control. McGraw-Hill Book Company.
2. Juran. (1988). Quality Control Handbook. McGraw-Hill Book Company.

E-Resources:

https://kanchiuniv.ac.in/coursematerials/ECE_COURSE_MATERIAL_ODD%20SEMESTER/ECE_COURSE%20MATERIAL_ODD%20SEMESTER/Mrs.V.UMA_TOTAL%20QUALITY%20MANAGEMENT.pdf

RENEWABLE ENERGY RESOURCES [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Understand the fundamental principles and social implications of renewable energy, and analyze its availability and applications worldwide and specifically in India. 2. Acquire knowledge of solar energy technologies, including the mechanics of solar radiation, thermal collectors, and photovoltaic systems. 3. Explore wind energy fundamentals, including wind characteristics, energy capture, and efficiency calculations for wind turbine installations. 4. Learn the processes involved in biomass energy production, including different biomass fuels, conversion techniques, and biogas generation. 5. Study the principles and applications of tidal and ocean thermal energy, and investigate new energy sources like hydrogen for sustainable development.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction	06 Hours
Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave	

energy, ocean thermal energy, biomass energy, geothermal energy, oil shale. Introduction to Internet of energy (IOE). <i>(Text Book-1: Chapter 1: 1.1 to 1.2)</i>	
UNIT – II: Solar Energy	10 Hours
Solar Energy- Solar radiation its measurements and prediction - solar thermal collectors - flat plate collectors, concentrating collectors – applications - heating, cooling, desalination, drying, cooking, etc. Principle of photovoltaic conversion of solar energy - types of solar cells and fabrication -photovoltaic applications - battery charging, domestic lighting, street lighting. <i>(Text Book-1: Chapter 2.1: 2.12).</i>	
UNIT – III: Wind Energy	08 Hours
Wind Energy- Wind energy - energy chains - application - historical background, merits and limitations - nature of wind - planetary and local day / night winds - wind energy quantum - power in wind- turbine efficiency - torque thrust calculations - velocity at different heights - site selection - components of wind energy conversion system (WECS). <i>(Text Book-1: Chapter 6: 6.1 to 6.16)</i>	
UNIT – IV: Energy from Biomass	06 Hours
Energy from biomass - biomass as renewable energy source - types of bio mass fuels - solid, liquid and gas - biomass conversion techniques- wet process, dry process photosynthesis-biogas generation - factors affecting bio- digestion - classification of bio gas plant - continuous, batch and fixed dome types - advantages and disadvantages . <i>(Text Book-1: (Chapter 07: 7.1 to 7.13)</i>	
UNIT – V: Tidal, Ocean Thermal Energy and New Energy Sources	09 Hours
Tidal Energy: tide – spring tide, neap tide – tidal range – tidal power – types of tidal power plant – single and dual basin schemes – requirements in tidal power plant - ocean thermal energy conversion (OTEC): principle - open and closed OTEC cycles. Hydrogen as a renewable energy source - sources of hydrogen - fuel for vehicles - hydrogen production.fuel cell – principle of working, construction and applications <i>(Text Book-1: Chapter 8,9 &11): 8.1 to 8.06,9. to 9.10 & 11.1 to 11.8)</i>	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Evaluate the global and local implications of renewable energy sources and apply sustainable practices and technologies in energy projects.	L1
2	Design and optimize solar energy systems for a variety of applications, including heating, cooling, and power generation, using knowledge of solar radiation and photovoltaic technologies.	L2
3	Analyze and implement wind energy solutions by understanding wind dynamics, assessing site potential, and calculating energy yields and system efficiencies.	L3
4	Develop and manage biomass energy projects by applying various conversion techniques and understanding the operational parameters of different types of biogas plants.	L2
5	Design and assess tidal and ocean thermal energy systems, and integrate emerging technologies such as hydrogen fuel cells into renewable energy solutions.	L3
Table: Mapping Levels of COs to POs / PSOs		

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)				2: Moderate (Medium)						1: Poor (Low)				

Textbooks:

1. Rai, G. D. (2010). Non-conventional Resources of Energy (4th ed.). Khanna Publishers.
2. Khan, B. H. (2009). Non-Conventional Energy Resources (2nd ed.). McGraw Hill.

Reference Books:

3. Rao, S., & Parulekar, B. B. (2005). Energy Technology (4th ed.). Khanna Publishers.
4. Mackay, D. J. C. (2009). Sustainable Energy – Without the Hot Air. UIT Cambridge.
(Note: Corrected publisher information for accuracy)

E-Resources:

1. <https://www.renewableenergyworld.com/>
2. <https://www.renewableenergyhub.co.uk/>
3. <https://www.edfenergy.com/energywise/renewable-energy-sources>
4. <https://www.energy.gov/eere/renewable-energy>

RAPID MANUFACTURING TECHNOLOGIES [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-S	: 3-0-0-0		
Course Learning Objectives:			
This Course will enable students to:			
1. Understand the historical development and fundamental principles of rapid prototyping technologies and their impact on modern manufacturing and design. 2. Gain proficiency in operating and applying various liquid-based, solid-based, and powder-based rapid prototyping systems. 3. Learn the technical aspects and applications of advanced rapid prototyping processes such as Stereolithography, Fused Deposition Modeling, and Selective Laser Sintering. 4. Explore the range of materials available for rapid prototyping, including polymers, metals, ceramics, and composites, and their specific applications in prototyping and manufacturing. 5. Acquire skills in reverse engineering methodologies, from data acquisition through contact and non-contact devices to the creation of CAD models and functional prototypes.			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.			
• Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : INTRODUCTION			06 Hours

History – Development of RP systems – Applications in Product Development, Reverse Engineering, Rapid Tooling, Rapid Manufacturing- Principle –Fundamental – File format – Other translators – medical applications of RP – On demand manufacturing – Direct material deposition - Shape Deposition Manufacturing.

UNIT – II: LIQUID BASED RAPID PROTOTYPING SYSTEMS

10 Hours

Classification – Liquid based system - Stereolithography Apparatus (SLA), details of SL process, products, Advantages, Limitations, Applications and Uses. Solid based system – Fused Deposition Modeling, principle, process, products, advantages, applications and uses - Laminated Object Manufacturing

UNIT – III: POWDER BASED RAPID PROTOTYPING SYSTEMS

08 Hours

Selective Laser Sintering – principles of SLS process, principle of sinter bonding process, Laser sintering materials, products, advantages, limitations, applications and uses. Three-Dimensional Printing – process, major applications, research and development. Direct shell production casting – key strengths, process, applications and uses, case studies, research and development. Laser Sintering System, e-manufacturing using Laser sintering, customized plastic parts, customized metal parts, e-manufacturing - Laser Engineered Net Shaping (LENS).

UNIT – IV: MATERIALS FOR RAPID PROTOTYPING SYSTEMS

06 Hours

Nature of material – type of material – polymers, metals, ceramics and composites liquid based materials, photo polymer development – solid based materials, powder-based materials – case study.

UNIT – V: REVERSE ENGINEERING AND NEW TECHNOLOGIES

09 Hours

Introduction, measuring device- contact type and non-contact type, CAD model creation from point clouds-preprocessing, point clouds to surface model creation, medical data processing - types of medical imaging, software for making medical models, medical materials, other applications - Case study.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Evaluate and select the most appropriate rapid prototyping technologies for specific applications in product development and manufacturing.	L1
2	Optimize the use of liquid-based and solid-based rapid prototyping systems to enhance product design and reduce development time.	L2
3	Integrate powder-based rapid prototyping methods, such as Selective Laser Sintering and 3D Printing, effectively in the creation of functional prototypes and end-use parts.	L3
4	Synthesize knowledge of various materials used in rapid prototyping to choose the best options based on the mechanical properties and application requirements.	L2
5	Implement advanced reverse engineering techniques to reconstruct accurate digital models from physical objects, particularly for customized medical applications.	L3
Table: Mapping Levels of COs to POs / PSOs		
COs	Program Outcomes (POs)	PSOs

	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbooks:

1. Noorani, R. I. (2005). Rapid Prototyping: Principles and Applications (1st ed.). Wiley & Sons.
2. Chua, C. K., Leong, K. F., & Lim, C. S. (2003). Rapid Prototyping: Principles and Applications (2nd ed.). World Scientific Publishing Co. Pvt. Ltd.

Reference Books:

1. Pham, D. T., & Dimov, S. S. (2001). Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling (1st ed.). Springer-Verlag London Limited.
2. Liou, F. F. (2007). Rapid Prototyping and Engineering Applications (2nd ed.). CRC Press.

PROFESSIONAL ELECTIVE IV

Industrial Automation and Control [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L–T–P–S	: 3–0–0–0		
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Examine the architecture and components of advanced industrial automation systems, emphasizing the integration and scalability of these systems within modern industries. 2. Understand and apply advanced control strategies such as Model Predictive Control, Fuzzy Logic, and Adaptive Control to optimize industrial processes. 3. Analyze the role and implementation of various industrial communication protocols and network designs, focusing on their impact on system performance and security. 4. Assess and implement safety and regulatory standards pertinent to industrial automation, with a focus on risk management and compliance. 5. Explore emerging technologies and trends in industrial automation, evaluating their potential to enhance efficiency, sustainability, and innovation in manufacturing processes.			
<u>Teaching-Learning Process (General Instructions)</u> These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Overview of Industrial Automation Systems			09 Hours
Automation Concepts and Components: Review of basic concepts in automation, emphasizing components not covered in basic courses, such as advanced sensors, actuators, and final control elements. System Architecture: Hierarchical structure of industrial automation systems including enterprise level, control level, and field level. Integration Challenges: Discussion on the integration of			

various automation components and systems within an existing industrial setup.	
UNIT – II: Advanced Control Strategies in Automation	09 Hours
Advanced Control Techniques: Beyond PID—Model Predictive Control (MPC), Fuzzy Logic Control, and Adaptive Control applications in industrial settings. Real-Time Control Systems: Exploration of real-time operating systems (RTOS) in industrial automation and the implications for system design and reliability. Data-Driven Control: Introduction to the role of big data and machine learning in predictive maintenance and process optimization.	
UNIT – III: Communication Technologies in Industrial Automation	06 Hours
Industrial Communication Protocols: Detailed examination of protocols like EtherCAT, Modbus, PROFIBUS, and PROFINET, and their applications in industrial automation. Network Design and Security: Designing robust industrial networks and addressing cybersecurity challenges in industrial control systems. Wireless and Mobile Communications: The use of wireless sensor networks and mobile devices in monitoring and controlling industrial processes	
UNIT – IV: Safety and Regulatory Standards	07 Hours
Safety Standards: In-depth look at international safety standards such as ISO 13849 and IEC 62061, and how they influence the design and operation of automation systems. Regulatory Compliance: Understanding the impact of regulations on industrial automation, focusing on environmental, safety, and quality control standards. Hazard Analysis and Risk Assessment: Techniques and methodologies for assessing risks and implementing safety measures in automated environments.	
UNIT – V: Case Studies and Emerging Trends	08 Hours
Innovative Applications: Exploration of cutting-edge applications in industrial automation such as collaborative robots, augmented reality in maintenance, and AI-driven process control. Sustainability and Energy Efficiency: Discussion on the role of automation in enhancing energy efficiency and sustainability in manufacturing processes. Future of Industrial Automation: A look at ongoing research, potential future technologies, and their expected impact on the field of industrial automation.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Design and evaluate the architecture of advanced industrial automation systems, demonstrating an ability to integrate various automation components effectively.	L2 & L3
2	Implement and critique advanced control strategies in simulated industrial scenarios, showcasing enhanced process efficiency and adaptability.	L2 & L3
3	Develop robust communication networks for industrial automation, applying knowledge of protocols and security measures to ensure reliable and secure operations.	L3

4	Apply international safety and regulatory standards to automation projects, ensuring compliance and prioritizing workplace safety and environmental sustainability.	L4
5	Assess and incorporate emerging technologies into industrial automation systems, demonstrating foresight and innovation in tackling future challenges in automation.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Krutz, R. L. (2016). Industrial Automation and Control System Security Principles (2nd ed.). ISA.
2. Love, J. (2007). Process Automation Handbook: A Guide to Theory and Practice. Springer.

Reference Books:

1. Lipták, B. G. (2005). Instrument Engineers' Handbook: Process Control and Optimization (4th ed.). CRC Press.
2. Groover, M. P. (2014). Automation, Production Systems, and Computer-Integrated Manufacturing (4th ed.). Pearson.

COMPUTATIONAL TOOLS FOR THE ADDITIVE MANUFACTURING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This Course will enable students to:

1. Provide students with a comprehensive understanding of the various types of additive manufacturing processes and their applications in industry.
2. Equip students with practical skills in using CAD software for designing and optimizing 3D models specifically for additive manufacturing.
3. Teach students how to perform finite element analysis (FEA) and computational fluid dynamics (CFD) simulations to assess and improve the structural and thermal performance of AM parts.
4. Enable students to develop and optimize process plans, including layer slicing, path planning, and toolpath generation, for efficient additive manufacturing operations.
5. Familiarize students with emerging technologies and innovations in additive manufacturing, including multi-material printing and the integration of AI and machine learning, and to critically assess their potential applications.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt the Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I : Introduction	09 Hours
Overview of Additive Manufacturing (AM), Types of AM processes (SLA, SLS, FDM, etc.), Applications of AM in various industries, Introduction to Computational Tools for AM, Overview of key software and tools (CAD, CAM, CAE, etc.), Basics of 3D modeling and design for AM	

UNIT – II: CAD and Design for Additive Manufacturing	09 Hours
Computer-Aided Design (CAD) Basics, Introduction to CAD software (SolidWorks, AutoCAD, Fusion 360, etc.), Creating and manipulating 3D models, Design considerations specific to AM, Advanced CAD Techniques for AM, Topology optimization, Generative design, Case studies of optimized designs for AM	
UNIT – III: Simulation and Analysis for Additive Manufacturing	06 Hours
Finite Element Analysis (FEA) for AM, Basics of FEA and its importance in AM, Software tools for FEA (ANSYS, Abaqus, etc.), Stress, strain, and thermal analysis of AM parts, Computational Fluid Dynamics (CFD) in AM, Basics of CFD and its applications in AM, Simulation of material flow in AM processes, Software tools for CFD (Fluent, COMSOL, etc.)	
UNIT – IV: Process Planning and Optimization	07 Hours
Process Planning for AM, Layer slicing and path planning, Toolpath generation, Software tools for process planning (Materialise Magics, Simplify3D, etc.), Process Parameter Optimization, Key process parameters in AM, Impact of parameters on part quality, Optimization techniques and software tools	
UNIT – V: Case Studies and Emerging Technologies	08 Hours
Case Studies in Additive Manufacturing, Industrial applications and success stories, Challenges and solutions in AM projects, Guest lectures from industry experts, Emerging Technologies in AM, Multi-material and hybrid AM, Integration of AI and machine learning in AM, Future trends and innovations in AM	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply CAD software to create and manipulate 3D models tailored for additive manufacturing processes.	L2 & L3
2	Analyze the structural and thermal performance of AM parts using finite element analysis (FEA) and computational fluid dynamics (CFD) simulations.	L2 & L3
3	Optimize process parameters to enhance the quality and efficiency of additive manufacturing operations.	L3
4	Develop comprehensive process plans including layer slicing, path planning, and toolpath generation for different AM technologies.	L4
5	Evaluate and integrate emerging technologies in additive manufacturing, such as multi-material printing and the use of AI and machine learning in AM processes.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3

CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbooks:

1. Gibson, I., Rosen, D., & Stucker, B. (2015). Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing. Springer.
2. Leary, M. (2019). Design for Additive Manufacturing: Developments in Plastic and Metal Printing. Elsevier.

Reference Books:

1. Zhou, K., & Yang, S. (2018). Additive Manufacturing: Materials, Processes, Quantifications and Applications. CRC Press.
2. Shah, J. J., Mäntylä, M., & Nau, D. S. (1995). Computational Methods for Design and Manufacturing. Prentice Hall

FUNDAMENTAL OF DRIVES AND DC MACHINE MODELING			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER- VII			
Subject Code	:	Credits	: 03
Hours/Week	: 03 Hours	Total Hours	: 39Hours
L-T-P-S	: 3-0-0-0		
Course Learning Objectives:			
This course will enable students to:			
1. understand the fundamental concepts of electric drives			
2. provide knowledge of power converters and inverters			
3. analyze the mathematical modeling, drives of SRM and induction motors			
4. introduce permanent magnet motor characteristics, drives			
5. provide knowledge of various charging technologies			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.			
• Lecture method means it includes not only traditional lecture method but different <i>types of teaching methods</i> that may be adopted to develop the course outcomes.			
• Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.			
• Show Video/animation films to explain the functioning of various concepts.			
• Encourage Collaborative (Group Learning) Learning in the class.			
• To make Critical thinking , ask at least three Higher-order Thinking questions in the class.			
• Adopt Problem-Based Learning , which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.			
• Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
• Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding.			
• Practical experimentation of material testing of different metals and alloys			
Unit-1			8 Hours
Electric Drives			
Concept of electric drives - Classifications - Types of loads - Four-quadrant drive - Dependence of loadtorque on various factors - Dynamics of motor-load combination - Steady state stability of an electric drive system - Load Equalization - Control and Analysis of DC drives fed through single-phase and three-phase semi-converter - full-converter - phase-controlled configuration - Vector control - Energy efficient drives -			

losses in electrical drive systems		
Unit-2		7 Hours
Power Converters for EV: Introduction – Performance parameters of DC-DC conversion – Step-up and step-down converters with RL load – Switching mode regulators – Buck converter – Boost converter – Buck-Boost converter – Cuk converter – Limitations of single stage conversion – Comparison of converters – Inverter's introduction – Performance parameters – Principle of operation – Three phase inverters – Voltage control of three phase inverter – Current source inverter.		
Unit-3		7 Hours
Induction Motor Drives: Poly-phase Induction Motor- Characteristics, equivalent circuit, phasor diagram, dq-modelling; Scalar control-based induction motor drive; Vector control-based induction motor drive SRM Motor Drives Characteristics - Power converters - Control methods - Rotor position sensing - Closed loop control - Sensor-less operation		
Unit-4		9 Hours
Permanent Magnet Motor Drives PMSM introduction - Working principle - Magnetic circuit analysis - Torque and emf equations - Power converter - Closed loop control – PMSM introduction – Working principle - Torque equation - Phasor diagram – dq modelling - Vector control based PMSM drive Generation and Transmission of Electrical Energy Introduction – Types of generating stations - Controlling the power balance between generator and load – Hydropower generation stations – Thermal generating stations - Components of power distribution system – Tower grounding – Equivalent circuit of a line - Evolution of Electric Grid - Smart Grid Concept - Difference between conventional and Smart Grid - Phasor Measurement Unit		
Unit-5		8 Hours
EV Charging Technology: EV charging technology - Types of charging systems - Schematic comparison between AC Charger and DC Fast charger - Charging standards - Fundamental principle of wireless charging - Wireless charging technologies - Comparison between Conductive and Inductive charging schemes of EV – Wireless charging methods for EVs. Contemporary issues: Guest lectures from Industries, Research and Development Organisations		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the principles of electric drives to analyze and control various types of loads and drive systems, including four-	L2 & L3

	quadrant drives and energy-efficient drives.	
2	Implement and evaluate different DC-DC converters and inverters, including buck, boost, buck-boost, and three-phase inverters, to optimize performance parameters for electric vehicle applications.	L2 & L3
3	Analyze and design control strategies for poly-phase induction motor drives and switched reluctance motor (SRM) drives, including both scalar and vector control methods.	L3
4	Develop and implement control methods for permanent magnet motor drives, including PMLDC and PMSM, utilizing magnetic circuit analysis, torque equations, and dq modeling.	L4
5	Evaluate and compare various EV charging technologies, including AC and DC charging systems, wireless charging technologies, and different charging standards, to enhance the efficiency and effectiveness of EV charging infrastructure	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Wildi, T. (2014). Electrical Machines, Drives, and Power Systems (6th ed.). Pearson India.
2. Mohan, N. (2011). Power Electronics: A First Course. John Wiley & Sons Inc.

Reference Books:

1. Krishnan, R. (2017). Permanent Magnet Synchronous and Brushless DC Motor Drives. CRC Press.
2. Muhammad, R. H., Narendra, K., & Ashish, R. K. (2014). Power Electronics Devices, Circuits and Applications. Pearson Education.

ENERGY MANAGEMENT AND ECONOMICS [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Understand the types and characteristics of various energy resources and systems 2. Explore strategies for managing energy demand and the principles behind energy pricing and market structures 3. Understand the principles and technologies used to enhance energy efficiency in various applications 4. Gain knowledge about various renewable energy technologies and their operational principles. Examine the policies and regulations that support the development and integration of renewable energy 5. Master advanced methods for the economic evaluation of energy projects, including lifecycle costing and risk analysis	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	06 Hours
INTRODUCTION TO ENERGY MANAGEMENT AND ECONOMICS: Overview of energy systems and types of energy resources, Fundamentals of energy management, Basic economic principles relevant to energy, The role of energy in the global economy, Energy policies and regulations.	
UNIT – II	08 Hours

ENERGY SUPPLY AND DEMAND MANAGEMENT:

Energy supply chain and infrastructure, Factors influencing energy demand, Demand-side management and load forecasting, Energy pricing and market structures, Economic analysis of energy supply and demand.

UNIT - III

09 Hours

ENERGY EFFICIENCY AND CONSERVATION:

Principles of energy efficiency, Technologies and practices for improving energy efficiency. Economic analysis of energy efficiency projects, Barriers and incentives for energy conservation, Case studies on successful energy efficiency programs

UNIT - IV

07 Hours

RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT:

Overview of renewable energy sources, Integration of renewable energy into the grid. Economic viability of renewable energy projects, Policy and regulatory frameworks for renewable energy, Environmental impacts and sustainability considerations.

UNIT - V

06 Hours

ECONOMIC ANALYSIS AND POLICY IN ENERGY:

Economic evaluation of energy projects (Cost-Benefit Analysis, Net Present Value, Internal Rate of Return), Energy policy analysis and its economic impacts, Energy market dynamics and investment strategies, Risk management in energy projects, Future trends in energy economics and policy.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze different types of energy resources and their roles in energy systems and the economy and also Evaluate the effectiveness of various energy management strategies in optimizing energy use.	L2 & L3
2	Analyze the components and efficiency of energy supply chains and infrastructure. Develop effective demand-side management strategies tailored to specific energy markets and consumer needs	L2 & L3
3	Evaluate various technologies and practices for their potential to improve energy efficiency across different applications. Create strategies to overcome barriers to energy conservation and promote energy-saving practices.	L3
4	Evaluate different renewable energy technologies for their operational principles, applications, and environmental impact. Develop policy recommendations that support the adoption and integration of renewable energy technologies.	L4
5	Apply advanced methods like lifecycle costing and risk analysis to evaluate the financial viability of energy projects.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

TEXT BOOKS:

1. Frank Kreith, D. Yogi Goswami (2017), Energy Management and Conservation Handbook, CRC Press.
2. Alan P. Rossiter and Beth P. Jones (2015), Energy Management and Efficiency for the Process Industries, John Wiley & Sons

REFERENCE BOOKS:

1. Francis Vanek, Louis Albright, and Largus Angenent (2020), Energy Systems Engineering: Evaluation and Implementation, McGraw-Hill Education.
2. Charles W. Donovan (2019), Renewable Energy Finance: Powering the Future, Imperial College Press

E-Resources:

1. <https://beeindia.gov.in/en>
2. <https://mnre.gov.in/>

COMPUTATIONAL FLUID DYNAMICS (CFD) [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Provide students with a thorough understanding of the governing equations of fluid dynamics and their applications in solving real-world fluid flow problems. 2. Equip students with the knowledge and skills to derive and apply finite difference and finite volume methods for solving diffusion and convection-diffusion equations. 3. Enable students to analyze and implement various discretization schemes, ensuring properties such as conservativeness, boundedness, and transportiveness in numerical solutions. 4. Teach students advanced flow field analysis techniques, including the use of pressure correction algorithms and staggered grid methods, for accurate simulation of fluid flow. 5. Familiarize students with turbulence modeling and mesh generation techniques, and train them in using CFD software tools for complex fluid dynamics simulations.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I Introduction	06 Hours
Governing equations and boundary conditions: Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-	

averaged equations for Turbulent Flow – Turbulent-Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.	
UNIT – II: Finite difference and finite volume methods for diffusion	08 Hours
: Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three –dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.	
UNIT – III: Finite volume method for convection diffusion	09 Hours
Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.	
UNIT – IV: Flow field analysis	07 Hours
Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.	
UNIT – V: Turbulence models and mesh generation	06 Hours
Turbulence models, mixing length model, Two equation (k-ε) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the governing equations of fluid dynamics, including continuity, momentum, and energy equations, to solve fluid flow problems with appropriate boundary conditions.	L2 & L3
2	Implement finite difference and finite volume methods to derive and solve diffusion problems in one, two, and three dimensions, utilizing both explicit and implicit schemes.	L2 & L3
3	Analyze convection-diffusion problems using various discretization schemes, such as central, upwind, hybrid, and QUICK schemes, to ensure properties like conservativeness and boundedness.	L3
4	Develop and apply flow field analysis techniques using finite volume methods, including the representation of pressure gradients, momentum equations, and pressure correction algorithms like SIMPLE and PISO.	L4
5	Evaluate and implement turbulence models and mesh generation techniques, including structured and unstructured grid generation, to improve the accuracy and efficiency of CFD simulations.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2

C01	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Versteeg, H. K., & Malalasekera, W. (2007). An Introduction to Computational Fluid Dynamics: The Finite Volume Method (2nd ed.). Pearson Education Ltd.
2. Ghoshdastidar, P. S. (1998). Computer Simulation of Flow and Heat Transfer. Tata McGraw Hill Publishing Company Ltd.

Reference Books:

1. Patankar, S. V. (2004). Numerical Heat Transfer and Fluid Flow. Hemisphere Publishing Corporation.
2. Chung, T. J. (2002). Computational Fluid Dynamics. Cambridge University Press.

PROFESSIONAL ELECTIVE V

Robot Manipulators [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Subject Code	:	Credits	03
Hours / Week	:	Total Hours	39 Hours
L-T-P-S	:	3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Explore advanced mechanical designs and configurations of robot manipulators to enhance functionality and performance in various applications. 2. Analyze sources of error and implement precision enhancement techniques to improve the accuracy and reliability of robot manipulators. 3. Master advanced control strategies for robot manipulators, focusing on non-linear control and force control to handle complex interaction dynamics. 4. Integrate and optimize the use of various sensors in robot manipulators to enable real-time feedback and sensor-based control in dynamic environments. 5. Investigate the application of robot manipulators in diverse industries, understanding the requirements and challenges of each sector, and examining future trends in manipulator technology.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. ● Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. ● Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. ● Show Video/animation films to explain functioning of various concepts. ● Encourage Collaborative (Group Learning) Learning in the class. ● To make Critical thinking, ask at least three Higher order Thinking questions in the class. ● Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. ● Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. ● Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Advanced Manipulator Mechanics			09 Hours
Mechanical Design of Manipulators: Study of structural aspects, materials, and design criteria for robustness and performance. Joint and Link Configurations: Analysis of different joint types (revolute,			

prismatic) and their influence on manipulator functionality. Grippers and End Effectors: Detailed examination of end effector design and functionality, including adaptive and smart grippers.	
UNIT – II: Precision and Accuracy in Robot Manipulators	09 Hours
Sources of Error: Identification of mechanical, electrical, and computational errors affecting accuracy. Error Compensation Techniques: Methods to enhance precision, including calibration and error modeling. Performance Metrics: Defining and evaluating performance metrics such as repeatability, accuracy, and resolution.	
UNIT – III: Advanced Control of Robot Manipulators	06 Hours
Non-linear Control Techniques: Strategies like feedback linearization and sliding mode control. Force Control Strategies: Including impedance and admittance control for handling interactions with environments. Redundancy Resolution: Techniques for utilizing extra degrees of freedom for optimization of control tasks.	
UNIT – IV: Integration of Sensors in Manipulators	07 Hours
Sensor Types and Placement: Discussion on the integration of tactile, force, and vision sensors into robot manipulators. Sensor-Based Control: Real-time sensor feedback integration in control schemes for enhanced adaptability. Sensor Fusion: Techniques to combine data from multiple sensors for improved decision-making and accuracy.	
UNIT – V: Applications and Emerging Technologies	08 Hours
Industry-Specific Applications: Customization of manipulators for sectors like automotive, electronics, and healthcare. Collaborative Robots (Cobots): Design and control considerations for robots working in direct interaction with humans. Innovative Technologies: Exploration of soft robotics, wearable robot arms, and other cutting-edge developments.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Design and analyze robot manipulators, incorporating joint configurations and end effector choices that meet specific industrial and research needs.	L2 & L3
2	Implement and evaluate error compensation techniques to maximize the precision and accuracy of manipulators in practical applications.	L2 & L3
3	Apply advanced control algorithms to enhance the functionality and adaptability of robot manipulators in complex operational environments.	L3
4	Integrate and optimize sensor technologies within manipulator systems to enable sophisticated, real-time control and decision-making capabilities.	L4
5	Critically assess and adapt manipulator technologies to solve specific challenges in industries such as healthcare, manufacturing, and service sectors.	L4

Table: Mapping Levels of COs to POs / PSOs

	Program Outcomes (POs)	PSOs

COs	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Paul, R. P. (1981). Robot Manipulators: Mathematics, Programming, and Control. MIT Press.
2. Craig, J. J. (2017). Introduction to Robotics: Mechanics and Control (4th ed.). Pearson.

Reference Books:

1. Mittal, R. K., & Nagrath, I. J. (2003). Robotics and Control. Tata McGraw-Hill Education.
2. Angeles, J. (2014). Fundamentals of Robotic Mechanical Systems: Theory, Methods, and Algorithms (4th ed.). Springer.

POWDER METALLURGY			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Subject Code	:	Credits	03
Hours / Week	:	Total Hours	39 Hours
L-T-P-S	:	3-0-0-0	
Course Learning Objectives:			
This Course will enable students to:			
1. Understand the principles and fundamentals of powder metallurgy as a manufacturing process. 2. Identify the different powder metallurgy techniques and their applications in various industries. 3. Gain knowledge of the properties and characteristics of powder materials used in manufacturing processes. 4. Analyze the advantages and limitations of powder metallurgy compared to conventional manufacturing methods. 5. Develop the skills necessary to design, produce, and assess powder metallurgy components.			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.			
• Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
Unit 1: Introduction to Powder Metallurgy			08Hrs
Overview of powder metallurgy and its historical development. Fundamentals of powder metallurgy processes. Powder characteristics and properties. Powder production methods.			
Unit 2: Powder Compaction and Shaping			09 Hours

Principles of powder compaction. Types of compaction presses and their operation. Tooling design for powder compaction. Post-compaction shaping techniques.	
Unit 3: Sintering and Heat Treatment	06 Hours
Fundamentals of sintering and its mechanisms. Sintering furnaces and atmosphere control. Sintering kinetics and densification. Heat treatment of powder metallurgy components.	
Unit 4: Secondary Operations in Powder Metallurgy	07Hrs
Debinding techniques for removing binders from green compacts. Post-sintering treatments (e.g., impregnation, infiltration, etc.). Finishing operations for powder metallurgy components.	
Unit 5: Powder Metallurgy Applications and Advanced Techniques	08 Hrs
Automotive applications of powder metallurgy components. Aerospace and defense industry applications. Powder metallurgy in biomedical and consumer goods. Metal injection molding (MIM) and its advantages. Powder forging and its application in producing high-strength components. Powder spraying and coating techniques.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply knowledge of powder characteristics and production methods to select appropriate powders for specific powder metallurgy processes.	L2 & L3
2	Design and implement tooling for powder compaction, optimizing press types and post-compaction shaping techniques.	L2 & L3
3	Analyze sintering mechanisms and kinetics to optimize furnace conditions and atmosphere control for enhanced densification.	L3
4	Execute secondary operations such as debinding, post-sintering treatments, and finishing techniques to improve the quality and performance of powder metallurgy components.	L4
5	Evaluate and integrate advanced powder metallurgy techniques like metal injection molding, powder forging, and powder spraying in various industrial applications.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. German, R. M. (2017). Powder Metallurgy Science (4th ed.). Metal Powder Industries Federation (MPIF).
2. Cantor, B., Campbell, F. C., & Grant, P. (2014). Powder Metallurgy: Principles and Applications (1st ed.). Cambridge University Press.

Reference Books:

1. Chang, I., Zhao, Y., & Chen, M. (Eds.). (2013). Advances in Powder Metallurgy: Properties, Processing, and Applications. Woodhead Publishing.
2. Angelo, P. C., & Subramanian, R. (2008). Powder Metallurgy: Science, Technology, and Applications. PHI Learning Pvt. Ltd.

ADVANCED ENERGY STORAGE			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER- VII			
Subject Code	:	Credits	03
Hours/Week	: 03 Hours	Total Hours	: 39Hours
L-T-P-S	: 3-0-0-0		
Course Learning Objectives:			
This course will enable students to:			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.			

- Show the <i>different ways to solve</i> the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every <i>concept can be applied to the real world</i> - and when that's possible, it helps improve the student's understanding. Practical experimentation of material testing of different metals and alloys	
Unit-1	8 Hours
Storage: Historical Perspective, Introduction and Changes: Storage Needs - Variations in Energy Demand - Variations in Energy Supply - Interruptions in Energy Supply - Transmission Congestion - Demand for Portable Energy - Demand and scale requirements - Environmental and sustainability issues.	
Unit-2	7 Hours
Technical Methods of Storage: Introduction: Energy and Energy Transformations, Potential energy (pumped hydro, compressed air, springs) - Kinetic energy (mechanical flywheels) - Thermal energy without phase change passive (adobe) and active (water) - Thermal energy with phase change (ice, molten salts, steam) - Chemical energy (hydrogen, methane, gasoline, coal, oil) - Electrochemical energy (batteries, fuel cells) - Electrostatic energy (capacitors), Electromagnetic energy (superconducting magnets) - Different Types of Energy Storage Systems	
Unit-3	7 Hours
Performance Factors of Energy Storage Systems: Energy capture rate and efficiency - Discharge rate and efficiency - Dispatch ability and load flowing characteristics, scale flexibility, durability - Cycle lifetime, mass and safety - Risks of fire, explosion, toxicity - Ease of materials, recycling and recovery - Environmental consideration and recycling, Merits and demerits of different types of Storage.	
Unit-4	9 Hours
APPLICATION CONSIDERATION: Comparing Storage Technologies - Technology options- Performance factors and metrics - Efficiency of Energy Systems - Energy Recovery - Battery Storage System: Introduction with focus on Lead Acid and Lithium - Chemistry of Battery Operation, Power storage calculations, Reversible reactions, Charging patterns, Battery Management systems, System Performance, Areas of Application of Energy Storage: Waste heat recovery, Solar energy storage, Green house heating, Power plant applications, Drying and heating for process industries, energy storage in automotive applications in hybrid and electric vehicles.	
Unit-5	8 Hours
Hydrogen Fuel Cells and Flow Batteries: Hydrogen Economy and Generation Techniques, Storage of Hydrogen, Energy generation - Super capacitors: properties, power calculations - Operation and Design methods - Hybrid	

Energy Storage: Managing peak and Continuous power needs, options - Level 1: (Hybrid Power generation) Bacitor “Battery + Capacitor” Combinations: need, operation and Merits; Level 2: (Hybrid Power Generation) Bacitor + Fuel Cell or Flow Battery operation- Applications: Storage for Hybrid Electric Vehicles, Regenerative Power, capturing methods.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze various energy storage needs and assess the impact of energy demand and supply variations on storage requirements.	L2 & L3
2	Apply technical methods to design and implement different energy storage systems, including potential, kinetic, thermal, chemical, electrochemical, electrostatic, and electromagnetic storage.	L2 & L3
3	Evaluate performance factors such as energy capture rate, discharge rate, efficiency, durability, and safety for various energy storage systems.	L3
4	Compare and select appropriate storage technologies based on performance metrics, efficiency, and application-specific requirements in areas such as waste heat recovery, solar energy storage, and automotive applications.	L4
5	Develop and integrate hydrogen fuel cells, flow batteries, and hybrid energy storage systems for managing peak and continuous power needs in applications like hybrid electric vehicles and regenerative power systems.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Stolten, D. (2010). Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications. Wiley.
2. Zhang, J., Zhang, L., Liu, H., Sun, A., & Liu, R.-S. (2012). Electrochemical Technologies for Energy Storage and Conversion. John Wiley & Sons.

Reference Books:

1. Béguin, F., & Frackowiak, E. (2013). Supercapacitors: Materials, Systems, and Applications. Wiley.
2. Doughty, D., Liaw, B. Y., Narayan, S. R., & Srinivasan, V. (2010). Batteries for Renewable Energy Storage. The Electrochemical Society.

ENERGY SYSTEMS MODELLING AND ANALYSIS [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Describe fundamental principles of energy system design. Explain heat transfer mechanisms and their significance in thermal systems 2. Develop MATLAB and Simulink models for basic energy system components 3. Assess the feasibility of integrating renewable energy sources into energy systems 4. Implement control strategies to improve the performance of thermal components 5. Present a project integrating theoretical concepts with practical applications in thermal system design.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	06 Hours
FUNDAMENTALS OF ENERGY SYSTEM DESIGN: Overview of energy system design principles, Heat transfer mechanisms: conduction, convection, and radiation, Design considerations for heat exchangers, boilers, and condensers Case studies on the application of thermal system design principles	
UNIT – II	08 Hours
MODELING AND SIMULATION OF ENERGY SYSTEMS:	

Introduction to MATLAB and Simulink for thermal system simulation, Dynamic modeling of boilers, turbines, and heat exchangers, Simulation of transient and steady-state behavior in thermal systems. Optimization techniques for thermal system performance

UNIT - III

08 Hours

INTEGRATION OF RENEWABLE ENERGY SYSTEMS:

Integration of solar thermal systems with boilers and heat exchangers , Modeling biomass combustion and its integration into thermal systems ' Economic analysis and lifecycle assessment of hybrid energy systems 'Case studies on successful integration of renewable energy with thermal systems

UNIT - IV

07 Hours

ADVANCED TOPICS IN ENERGY SYSTEM OPTIMIZATION:

Optimization algorithms for thermal energy systems , Advanced control strategies for boilers, turbines, and heat exchangers ,Emerging technologies in thermal energy, such as waste heat recovery and cogeneration , Case studies on successful application of optimization and control in thermal systems

UNIT - V

07 Hours

CASE STUDIES AND PROJECT IN ENERGY SYSTEM DESIGN:

Case Studies Analysis: Detailed analysis of successful and challenging applications of energy system design principles. Examples may include retrofitting of existing systems, integration of renewable energy, and industrial applications.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze fundamental principles of energy system design using governing laws of heat transfer, fluid mechanics and thermodynamics	L2 & L3
2	Design intricate MATLAB and Simulink models to simulate and predict the behavior of complex thermal systems. Innovate and propose improvements based on simulation results to optimize energy system performance.	L2 & L3
3	Critique and justify the integration of diverse renewable energy sources into thermal systems and synthesize economic, environmental, and technical factors to propose sustainable hybrid energy solutions.	L3
4	Devise and execute advanced optimization algorithms to maximize energy efficiency and operational performance in thermal systems. Formulate and implement adaptive control strategies to enhance the dynamic response and stability of thermal components.	L4
5	Construct a comprehensive project integrating theoretical concepts with practical applications in energy system design. Justify project outcomes using systematic analysis and evidence-based reasoning	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Stoecker, W. F. (1981). Design of Thermal Systems. McGraw-Hill Education.
2. Dabney, J. B., & Harman, T. L. (2015). Mastering Simulink. Pearson.

Reference Books:

1. Lund, H. (2014). Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions. Academic Press.
2. Sastry, S. S. (1988). Introductory Methods of Numerical Analysis. Prentice Hall.
3. Knopf, F. C. (2012). Modeling, Analysis, and Optimization of Process and Energy Systems. Wiley.

TOOL DESIGN	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand the various types of tooling materials and their industrial applications. 2. Develop capability to design and select single point and multipoint cutting tools for various machining operations. 3. Exposure to variety of locating and clamping methods available. 4. Design jigs and fixtures for simple components 5. Design/selection procedure of sheet metal and injection mold	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	06 Hours
Different tooling materials: cemented carbides, coated carbides, cermet's, ceramics and polycrystalline tool materials. Selection and properties of tool materials, plastics as tool materials, Tooling materials – properties and applications of ferrous, non-ferrous and non-metallic materials. Case studies.	
UNIT – II	08 Hours
Design of single point cutting tools - various systems of specifications, geometry and their interrelation, theories of formation of chip and their effect. Design of multipoint cutting tools – Design elements, nomenclature and geometry of drill bit, milling cutter, reamer and broaching	

tool. Cutting parameters and machining time calculation for drilling, milling, reaming and broaching operation. Case studies

UNIT - III		08 Hours
Working of a power press and classification of presses. Press working terminology, Types of dies-Simple, progressive, compound and combination dies. Components of a simple die, press tool operation, die accessories, press tool operations. Shearing theory, cutting clearance between punch and die, methods of reducing cutting forces, Centre of pressure and problems, scrap strip layout. Design problems on blanking and piercing dies for simple components. Case studies		
UNIT - IV		07 Hours
Injection moulding machine and its elements, general configuration of a two plate mould. Introduction to gate, runner, parting surface, ejection system. Core and cooling system. Design problems on injection mold. Case studies		
UNIT - V		07 Hours
Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures. Location: 3-2-1 Principle of location, different types of locating elements. Clamping: Principles of clamping, types of clamping devices. Drill jigs: Different types, Types of fixtures: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centres, and modular fixtures. Case studies.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Select and evaluate different tooling materials, including cemented carbides, coated carbides, cermets, ceramics, and polycrystalline tool materials, based on their properties and applications.	L2 & L3
2	Design single and multipoint cutting tools, understanding their specifications, geometry, and the theories of chip formation, and calculate cutting parameters and machining time for various operations.	L2 & L3
3	Analyze the working and classification of power presses, and design various types of dies, including simple, progressive, compound, and combination dies, while solving design problems related to blanking and piercing dies.	L3
4	Develop and optimize injection molding processes, including the design of molds, gates, runners, parting surfaces, ejection systems, and cooling systems, with a focus on practical design problems.	L4
5	Design and implement jigs and fixtures for mass production, applying principles of location and clamping, and creating solutions for various machining operations, including turning, milling, grinding, and CNC machining.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3

C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Donaldson, C., LeCain, G. H., Goold, V. C., & Ghose, J. (2012). Tool Design. Tata McGraw-Hill.
2. Basu, S. K., Pal, D. K., & Mukherjee, S. C. (2009). Fundamentals of Tool Design. Oxford and IBH Publishing Co. Pvt. Ltd.

Reference Books:

1. Bhattacharyya, A. (2011). Metal Cutting and Tool Design. New Central Book Agency.
2. Jain, R. K. (2008). Production Technology. Khanna Publishers.

Major Project Phase-1 [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Develop the ability to identify and formulate engineering problems. 2. Apply theoretical knowledge and practical skills to design and implement engineering solutions. 3. Foster teamwork and collaborative problem-solving abilities. 4. Enhance project management and communication skills. 5. Promote innovation and creativity in addressing real-world engineering challenges.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
Content	06 Hours
1. Identification of Problem Based on Literature Review: • Conduct a thorough literature review to identify gaps or opportunities in existing research. • Formulate a clear problem statement based on findings. 2. Finding the Supervisor: • Identify and approach faculty members with expertise in the relevant field. • Discuss the project idea and seek guidance to finalize a supervisor. 3. Finalizing Methodology/Design Phase:	

- Define the research methodology, including experimental design, simulations, or theoretical analysis.
- Develop detailed design specifications and project plan, outlining objectives, resources, and timelines.

4. Report submission and presentation

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Synthesize information from various sources to identify research gaps or opportunities.	L3
2	Formulate a precise problem statement grounded in the findings of the literature review.	L3
3	Design a comprehensive research methodology, including experimental design, simulations, or theoretical analysis, and develop detailed design specifications and a project plan outlining objectives, resources, and timelines.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3										2		3
CO2	3	3	2									2		3
CO3	3	3										1		3

Major Project Phase-2 [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VIII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: - Develop the ability to identify and formulate engineering problems. - Apply theoretical knowledge and practical skills to design and implement engineering solutions. - Foster teamwork and collaborative problem-solving abilities. - Enhance project management and communication skills. - Promote innovation and creativity in addressing real-world engineering challenges.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. - Show Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, ask at least three Higher order Thinking questions in the class. - Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. - Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
Content	06 ours
1. Execution: - Implement the project plan, focusing on developing prototypes, conducting experiments, and collecting data. - Apply engineering principles and problem-solving techniques to address challenges and refine designs. 2. Result Discussion: - Analyze collected data to draw meaningful insights and validate the project objectives.	

- Compare results with theoretical predictions and previous studies to assess the accuracy and reliability.

3. Conclusion:

- Summarize key findings and their implications for the field of study.
- Provide recommendations for future research or improvements based on the project's outcomes.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Execute project plans by developing prototypes, conducting experiments, and refining designs using engineering principles.	L3
2	Analyze and interpret experimental data to draw meaningful conclusions and validate project objectives.	L3
3	Summarize findings, compare with theoretical predictions, and provide recommendations for future research or improvements.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3										2		3
CO2	3	3	2									2		3
CO3	3	3										1		3



Dayananda Sagar University
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District- 562112

SCHEME AND SYLLABUS

B.Tech. PROGRAMME– 2022 BATCH

Definitions / Descriptions

Definition of Credit:	
1 Hour Lecture (L) Per Week	01 Credit
1 Hour Tutorial (T) Per Week	0.5 Credit
1 Hour Practical (P) Per Week	0.5 Credit
1 Hour Project (J) Per Week	0.5 Credit

Course code and Definition:	
BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management Courses
IPCC	Integrated Professional Core Course
PCC	Professional Core Courses
PEC	Professional Elective Courses
OEC	Open Elective Courses
SEC	Skill Enhancement Courses
UHV	Universal Human Value Course
PROJ	Project Work
INT	Internship

Implementation of National Education Policy (NEP) 2020 for the B.Tech students of Batch 2022-23

The implementation of Curriculum follows NEP 2020 and addresses the following features and categories of courses:

1. Student Centric flexible curriculum.
2. Inter-disciplinary Courses,
3. Multi-disciplinary Courses,
4. Ability Enhancement Courses,
5. Skill Enhancement Courses,
6. Value Added Courses,
7. Product Design and Development,
8. Internship (Rural Internship, Industry Internship, Research/Development Internship), and
9. Multiple Exit and Multiple Entry
 - Certificate in Engineering after completion of first year.
 - Diploma in Engineering after completion of second year.
 - Advanced Diploma in Engineering after completion of third year.
 - Degree in Engineering after completion of fourth year

SCHEME 2022 - 2026 Batch

Department of Mechanical Engineering

III SEMESTER

III SEMESTER													
S. N	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	BSC	22ME2301	Transforms and Numerical Techniques	MAT	3	0	0	0	03	60	40	100	3
2	IPCC	22ME2302	Engineering Materials	Mech	2	0	2	0	03	60	40	100	3
3	IPCC	22ME2303	Fluid Mechanics and Machines	Mech	3	0	2	0	03	60	40	100	4
4	IPCC	22ME2304	Machining Process and Metrology	Mech	2	0	2	0	03	60	40	100	3
4	PCC	22ME2305	Thermodynamics	Mech	3	0	0	0	03	60	40	100	3
5	IPCC	22ME2306	Computer Aided Machine Drawing	Mech	1	0	4	0	05	60	40	100	3
6	AEC	22LSXXXX	Liberal Studies – I	Any Dept.	1	0	0	0	01	100	--	100	1
7	SEC	22ME23XX	Skill Enhancement Course – I	Mech	1	0	2	0	02	100	--	100	2
			Total		16	0	12	0	23				22

Skill Enhancement Course – I

	Autodesk Innovation Lab		22ME2307
	Bosch Rexroth Innovation Lab		22ME2308

IV SEMESTER													
S. N	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
1	BSC	22ME2401	Probability and Statistics	MAT	3	0	0	0	03	60	40	100	3
2	IPCC	22ME2402	Applied Thermal Systems	Mech	3	0	2	0	03	60	40	100	4
3	PCC	22ME2403	Kinematics and Dynamics ofMachines	Mech	3	0	0	0	03	60	40	100	3
4	PCC	22ME2404	Mechanics of Solids	Mech	3	0	0	0	03	60	40	100	3
5	IPCC	22ME2405	Heat Transfer	Mech	3	0	2	0	02	60	40	100	4
6	IPCC	22ME2406	Machine learning	Mech	2	0	2	0	04	60	40	100	3
7	SEC	22ME2407	Special Topics	Mech	0	0	2	0	01	100	--	100	1
8	SEC	22ME24XX	Skill Enhancement Course – II	Mech	1	0	2	0	02	100	--	100	2
			Total		18	0	10		21				23

Skill Enhancement Course – II			
	Autodesk Innovation Lab		22ME2408
	Bosch Rexroth Innovation Lab		22ME2409

V SEMESTER													
S. N	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	PCC		Microprocessors and Microcontrollers	Mech/EC E	3	0	0	0	03	60	40	100	3
2	PCC		Cloud Computing & Data Processing	Mech/CS E	2	1	0	0	03	60	40	100	3
3	IPCC		Design of Machine Elements	Mech	3	0	2	0	05	60	40	100	4
4	IPCC		Industrial Automation and Robotics	Mech	2	0	2	0	04	60	40	100	3
5	IPCC		Thermal management of Electronic devices	Mech	2	0	2	0	04				3
6	PEC		Professional Elective Course – I/MOOC	Mech	3	0	0	0	03	60	40	100	3
7	SEC		Skill Enhancement Course – III	Mech	1	0	2	0	03				2
			Total		16	0	10	0	26				21

Skill Enhancement Course – III			
	CAE Lab-I (CATIA)		XXXXX
	CAE Lab-II (ANSA)		XXXXX

VI SEMESTER													
S.N	Course Type	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practica	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	HSMC		Management and Entrepreneurship	Mech/Guest	3	0	0	0	03	60	40	100	3
2	IPCC		Finite Element method	Mech	3	0	2	0	05	60	40	100	4
3	PCC		Mechanical Vibrations	Mech	2	0	2	0	04	60	40	100	3
4	OEC		Open Elective – I	---	3	0	0	0	03	60	40	100	3
5	PEC		Professional Elective Course – II/MOOC	Mech	3	0	0	0	03	60	40	100	3
6	PEC		Professional Elective Course – III	Mech	3	0	0	0	03	100	--	100	3
7	PROJ		Minor Project	Mech	0	0	0	4	04	100	--	100	2
8	INT		Internship	Mech	Completed during intervening period of IV and V sem				--	100	--	100	2
			Total		18	--	2	4	24				23

VII SEMESTER												
S.N	Course Type	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
				Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	J					
1	HSMC	Fundamentals of Economics	Mech	3	0	0	0	03	60	40	100	3
2	IPCC	Instrumentation and Control	Mech	2	0	2	0	03	60	40	100	3
3	OEC	Open Elective – II	--	3	0	0	0	03	60	40	100	3
4	PEC	Professional Elective Course – IV / MOOC	Mech	3	0	0	0	03	60	40	100	3
5	PEC	Professional Elective Course – V	Mech	3	0	0	0	03	60	40	100	3
6	PROJ	Major Project Phase 1	Mech	0	0	0	06	03	100	--	100	3
		Total		16	0	4	6					18

VIII SEMESTER												
S.N	Course Type	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
				Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	J					
1	PROJ	Major Project-Phase 2	Mech	0	0	0	22	03	60	40	100	11
2	INT	Research Internship/ Industry Internship	Mech	0	0	6	0	03	100	--	100	03
		Total										14

NOTE: Total Credits (I-Sem to VIII Sem) = 163 credits.

S.N	Domain-wise	Domain Clusters	PROFESSIONAL ELECTIVE COURSES				
			PEC-I	PEC-II	PEC-III	PEC-IV	PEC-V
			5 th Semester	6 th Semester		7 th Semester	
1	Domain-1	ROBOTICS & AUTOMATION	Sensors & Actuators	Drives & Control systems	Robot Kinematics and Dynamics	Industrial Automation and Control	Robot Manipulators
2	Domain-2	ADDITIVE MANUFACTURING	Automated Manufacturing Systems	Materials for Additive Manufacturing	Processing Of Plastics & Composites	Computational Tools for Additive Manufacturing	Powder Metallurgy
3	Domain-3	HYBRID & ELECTRIC VEHICLES	Introduction to Hybrid & Electric Vehicles	Autotronics	Automotive Chassis & Transmission Systems	Fundamental of Drives and DC Machine Modeling	Advanced Energy Storage
4	Domain-4	RENEWABLE ENERGY	Solar Energy Engineering	Wind and biomass energy	Hydrogen Energy and Storage	Energy management and economics	Energy system modelling and applications
5	Domain-5	General Mechanical Engineering	Refrigeration and Air-conditioning	Micro Electro Mechanical Systems (MEMS)	Total Quality Management	Computational Fluid Dynamics (CFD)	Tool Design

OPEN ELECTIVES:

Open Elective -I (OEC-I)	Open Elective -II (OEC-II)
• Fluids & Thermal Engineering • Materials for Engineering applications • Industrial Robotics	• Automobile Engineering • Total Quality Management and Reliability • Renewable Energy Sources • Rapid Manufacturing Technologies

MINORS DEGREE PROGRAM

Sl. No	Course Name	Credits	Semester
1	Engineering Materials	3	3
2	Mechanics of Solids	3	4
3	Thermal System Engineering	3	5
4	Digital Manufacturing (Theory & Practice)	3	5
5	Product Design and development (Theory & Practice) -	3	6
6	Advances in Mechanical Engineering (Robotics, Electric Vehicle & Green Energy)	3	7
		18	

General Instructions:

- **Open Elective Courses:** At least two courses must be provided from each department and the courses shall be general course on emerging areas with broad coverage of syllabus so that student shall chose without any difficulty.
- **Honors Degree:** An Honors degree typically refers to a higher level of academic achievement in the major area. That is, certificate in his/her OWN major for Research orientation. The Credit requirement: **172 to 178 credits** (Major worth 160 credits + Honors 12 to 18 credits)
- **Minor Degree:** Minor is a secondary concentration of courses that often complements the honors. Minor in any OTHER branch for Improving Employability.
 - Minor is an option rather than a requirement for B. Tech students. They may opt for one of the Engineering or Non-engineering discipline as Minor, earning additional credits ranging from 12 to 18. However, students are permitted to choose only one Minor either from engineering or Non-engineering discipline.
 - This opportunity is ideal for students who took a Major out of necessity but would still like to pursue their passion in another discipline or to enrich/equip them for a specific profession where greater job opportunities exist. Another advantage of opting for a Major with a Minor is to earn standing credits for pursuing a Master's degree abroad or within India too.
 - Only students who satisfy a set of minimum eligibility criteria set forth by the university and meet certain pre-requisites, will be permitted to opt for a Minor.
 - Credit requirement: **172 to 178 credits** (Major worth 160 credits + Minor 12 to 18 credits)
 - Degree nomenclature: The degree will contain the Major / Major with Specialization. The Minor pursued by the student will be provided in the transcript along with details on courses completed and associated credits earned.
 - For e.g., For a student who pursued Computer Science and Engineering with a Minor in Industrial Psychology, the degree will read "B. Tech in Computer Science and Engineering", Transcripts of B. Tech will reflect the Minor courses and the Minor certificate in Industrial Psychology will be issued separately.

TRANSFORMS AND NUMERICAL TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 22ME2301	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-S	: 3-0-0-0		

Course Learning Objectives:

This Course will enable students to:

1. **Apply** their knowledge of Laplace transforms and inverse Laplace transforms to proficiently solve linear ordinary differential equations with constant coefficients, facilitating the analysis and modelling of complex systems.
2. **Analyze** periodic functions using Fourier series, assessing the convergence properties and precision of the series expansion, thereby enhancing their ability to understand and manipulate periodic phenomena.
3. **Utilize** complex exponential form, Fourier transforms of basic functions, and Fourier sine and cosine transforms to solve problems involving Fourier integrals, developing proficiency in applying these techniques to various mathematical scenarios.
4. **Employ** numerical methods, including Euler's Method, Runge-Kutta 4th order, Adams-Bashforth, and Adams-Moulton Methods, to solve differential equations and effectively analyze dynamic systems, enabling them to model real-world phenomena and make accurate predictions.
5. **Apply** finite difference methods, including the Crank-Nicolson method and appropriate techniques for hyperbolic PDEs, to effectively solve different types of partial differential equations (PDEs) such as elliptic, parabolic, and hyperbolic equations, enhancing their problem-solving skills in the context of differential equations and their applications.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I: Laplace Transform and Inverse Laplace Transform	09 Hours
Laplace Transforms of Elementary functions (without proof), (<i>Text Book-1: Chapter 6: 203 to 207</i>). Laplace Transforms of $e^{at}f(t)$, $t^n f(t)$ and $\frac{f(t)}{t}$, Periodic functions, Unit step function and impulse functions (<i>Text Book-1: Chapter 6:208-230</i>). Inverse Laplace Transforms- By the method of Partial Fractions, Logarithmic and Trigonometric functions, Convolution Theorem, Inverse Laplace transform using Convolution Theorem (<i>Text Book-1: Chapter 6: 238</i>). Solution to Differential Equations by Laplace Transform. (<i>Text Book-1: Chapter 238-242</i>).	
UNIT – II: Fourier Series	09 Hours
Periodic Functions, Trigonometric Series (<i>Text Book-1: Chapter 11: 495</i>). Fourier series Standard function, Functions of any Period $2L$, Even and Odd functions, Half-range Expansions. (<i>Text Book-1: Chapter 11: 483-492</i>). Practical Harmonic analysis (calculate average power and RMS values of periodic waveforms)	
UNIT – III: Fourier Transform	06 Hours
Calculation of Fourier integrals using complex exponential form (<i>Text Book-1: Chapter 11: 510</i>). Fourier transform of basic functions (<i>Text Book-1: Chapter 11: 510-516</i>). Fourier sine and cosine transforms. (<i>Text Book-1: Chapter 11: 518-522</i>).	
UNIT – IV: Numerical Methods for Solving Ordinary Differential Equations	07 Hours
Euler's Method-Basic principles of Euler's method for solving first-order ODEs (<i>Text Book-1: Chapter 1:10-12</i>). Runge-Kutta 4th order (<i>Text Book-1: Chapter 21:904</i>). Multistep Methods-Explanation of multistep methods (Adams-Bashforth, Adams-Moulton Methods) (<i>Text Book-1: Chapter 21:911-913</i>). Second-Order ODE. Mass-Spring System (Euler Method, Runge-Kutta Methods) (<i>Text Book-1: Chapter 21:916-918</i>).	
UNIT – V: Numerical Methods for Partial Differential Equations	08 Hours
Classification of PDEs (elliptic, parabolic, hyperbolic), (<i>Text Book-1: Chapter 21:922-923</i>). Finite Difference Methods (Laplace and Poisson Equations), Derivation of finite difference approximations (<i>Text Book-1: Chapter 21:923-927</i>). Crank-Nicolson Method (<i>Text Book-1: Chapter 21:938-941</i>). Method for Hyperbolic PDEs (<i>Text Book-1: Chapter 21:943-945</i>).	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply Laplace transforms and inverse Laplace transforms to solve linear ordinary differential equations with constant coefficients, demonstrating proficiency in system analysis and modelling.	L3
2	Analyze periodic functions using Fourier series and evaluate the convergence properties and precision of the series expansion.	L2 & L3
3	Solve problems involving Fourier integrals by applying complex exponential form, Fourier transforms of basic functions, and Fourier sine and cosine transforms.	L3
4	Utilize numerical methods such as Euler's Method, Runge-Kutta 4th order, Adams-Bashforth, and Adams-Moulton Methods to solve differential equations and analyze dynamic systems	L2 & L3
5	Apply finite difference methods, including the Crank-Nicolson method and appropriate techniques for hyperbolic PDEs, to solve various types	L3

	of partial differential equations (PDEs) such as elliptic, parabolic, and hyperbolic equations.													
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	2	2	1					1					
C02	3	2	2						1					
C03	3	2	2	1					1					
C04	3	2	2	1					1					
C05	3	2	2	1					1					
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

TEXT BOOKS:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 2015, 10th Edition, Wiley India.

REFERENCE BOOKS:

1. Higher Engineering Mathematics, B.S. Grewal, 2015, 43rd Edition, Khanna Publishers.
2. Higher Engineering Mathematics, John Bird, 2017, 6 th Edition, Elsevier Limited.

E-Resources:

1. <https://nptel.ac.in/courses/111106139>
2. <https://nptel.ac.in/courses/111101164>
3. <https://nptel.ac.in/courses/111105038>

ENGINEERING MATERIALS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 22ME2302	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 26+26 Hours
L-T-P-S	: 2-0-2-0		

Course Learning Objectives:

This course will enable students to:

1. **Analyse** the atomic/molecular structure difference between crystalline and non-crystalline materials.
2. **Determine** the tensile, compression, shear, and bending deformations of the metal specimen and describe the changes in specimen profile up to the point of fracture.
3. **Explain** the various phases present, composition, and mass fractions of the phases from a binary phase diagram.
4. **Understand** the types and applications of ceramics and polymers.
5. **Learn** the different manufacturing processes for composite materials.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I	05 Hours
INTRODUCTION TO MATERIALS: Introduction to materials, Overview of Crystal Structure, Solid Solutions, Hume Rothery Rules, Crystal Imperfections, Critical nucleus size, and Critical Free Energy. <i>(Text Book-1: Chapter 3: 3.1 to 3.7)</i> CRYSTALLIZATION: Mechanism of Crystallization, Nucleation, Nucleation- Growth, Single crystal, Polycrystalline Materials, Basic principles of solidification of metals and alloys. Solidification time, Cooling curves, Non- crystalline solids. functions <i>(Text Book-1: Chapter 3: 3.8, 3.17)</i>	
UNIT - II	05 Hours
TESTING OF MATERIALS: Testing of materials under tension, compression, and shear loads, Hardness tests, fatigue, and creep test. Impact testing. <i>(Text Book-1: Chapter 6: 6.6 to 6.11)</i> FATIGUE AND FRACTURE TEST: Fatigue testing, Fracture, Types, Fracture mechanics. Characteristics of creep curve & steady-state creep. Fracture toughness & fatigue, Stress, and temperature effects. <i>(Text Book-1: Chapter 8: 8.1 to 8.11)</i>	
UNIT - III	06 Hours
EQUILIBRIUM PHASE DIAGRAMS: Particle strengthening by precipitation. Precipitation reactions. Phase Rule, Unary System, Binary Phase diagrams, and Iron-carbon system. <i>(Text Book-1: Chapter 9: 9.1 to 9.6)</i> PHASE TRANSFORMATIONS. Transformation rate effects and Isothermal transformations (TTT Curves), Continuous cooling transformations, Microstructure and property changes in the iron-carbon system, Iron-carbon equilibrium diagram, and Heat treatments. <i>(Text Book-1: Chapter 9: 9.17 to 9.20, Chapter 11: 11.8 to 11.9)</i>	
UNIT - IV	05 Hours
STEEL AND MATERIAL PROPERTIES: Classification of steels and cast iron, Microstructure, Effect of alloying elements on steel, Ferrous alloys, and their applications, High Resistivity and High-temperature alloys, Selection of material for various applications- case studies. <i>(Text Book-1: Chapter 24: 24.1 to 24.3)</i> CERAMICS: Ceramics, Glass Ceramics, Advanced Ceramics, Functional properties and applications of ceramic materials and Glasses. <i>(Text Book-1: Chapter 12: 12.1 to 12.11)</i>	
UNIT - V	05 Hours
OPTICAL PROPERTIES OF MATERIALS Electromagnetic radiation, light interaction with solids, atomic and electronic interaction, refraction, reflection, and absorption. <i>(Text Book-1: Chapter 21: 21.1 to 21.7)</i> Light-emitting diodes, lasers, and optical fibers in communication <i>(Text Book-1: Chapter 21: 21.13, 21.14)</i>	
LAB COMPONENT	
1. Tension Test- To understand the tensile characteristics of mild steel through tensile testing and thereby determine mechanical properties such as ultimate tensile strength, elastic modulus, proportionality limit, yield point, fracture stress, percentage elongation & reduction in area. 2. Compression Test- To determine the compressive strength of aluminium and cast-iron specimens and to identify the failure modes of ductile/brittle materials through evaluation of their failure modes of the above material.	

3. Shear Test - To determine the ultimate shear strength of aluminium under single and double shear.
4. Bending Test - To investigate the relationship between load and span on the deflection of a simply supported beam subjected to a concentrated load at the center. Also, evaluate the modulus of elasticity of the given beam from the test data.
5. Impact Test (Charpy and Izod) - To evaluate the energy absorbed during failure of a notched specimen subjected to pendulum impact testing.
6. Brinell hardness Test -To determine the Brinell Hardness Number (BHN) of the given specimens.
7. Vicker's Hardness Test - To determine Vickers Hardness Number for a given specimen.
8. Wear Test - To understand the parameters that affect the wear rate using pin and disc apparatus.
9. Composite preparation- preparation of polymer composites through hand lay-up, vacuum bagging, and resin transfer molding process.
10. Demonstration of 3D printing of given polymer/metal/ceramic specimens

Course Outcomes:

At the end of the course, the student will be able to:

- Classify engineering materials based on their crystal structure
- Calculate the material properties through testing of materials
- Interpret phase diagram for alloy preparation
- Analyze the phase diagram, microstructure and the mechanical properties of materials
- Select material for an application by analyzing the requirements with the material properties
- Develop polymer composites by hand lay-up, vacuum bagging, resin transfer molding and filament winding processes

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	1
C02	3	3	3	3	3								2	1
C03	3	3	3	3	2								2	1
C04	3	3	3	3	3								2	1
C05	3	3	3	3	3								2	1
C06	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. William D. Callister, Jr. (2020) "Materials Science and Engineering an Introduction", 2nd Edition, John Wiley & Sons, Inc.
2. V. Raghavan (2019), "Materials Science and Engineering", Prentice–Hall of India Pvt. Ltd

REFERENCE BOOKS:

1. J.M. Shackelford (2014), Introduction to Materials Science for Engineers, 5th Edition, Prentice Hall, Inc.
2. Suryanarayana, A. V. K. (2020), Testing of Metallic Materials, Prentice Hall India, New Delhi.
3. W. Bolton (2013), Engineering materials technology, 3rd Edition, Butterworth & Heinemann.

E-Resources:

1. <https://nptel.ac.in/courses/113107078>
2. <https://nptel.ac.in/courses/103105219>
3. <https://nptel.ac.in/courses/112107221>
4. <https://www.coursera.org/learn/crystal-structures-and-properties-of-metals?>

Activity-Based Learning (Suggested Activities in Class)

1. Real-world problem-solving and puzzles using group discussion. E.g. material identification, microstructure study of materials using an Optical microscope, etc.,
 2. Demonstration of the fabrication of material using different techniques like stir casting, Hand layup, etc.
-

FLUID MECHANICS AND MACHINES [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – III			
Subject Code	: 22ME2303	Credits	: 04
Hours / Week	: 05 Hours	Total Hours	: 39+26 Hours
L-T-P-S	: 3-0-2-0		
Course Learning Objectives: This Course will enable students to: 1. Define basic properties of fluids and understand the continuum approximation. 2. Describe Lagrangian and Eulerian Approach for fluid flow Buckingham's Pi theorem 3. Apply dimensional analysis to design new pumps or turbines that are geometrically similar to existing pumps or turbines 4. To study the performance parameters of Impulse and Reaction turbines like Pelton wheel turbine, Francis turbine and Kaplan turbine 5. To study the performance parameters of Reciprocating, Centrifugal and Gear pumps			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I			08 Hours
Fluid Properties and Fluid Statics Introduction, properties of fluids, viscosity, thermodynamics properties, surface tension and capillarity, vapour pressure. Types of fluid flows Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmospheric and vacuum pressures, Fluid Statics: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid. (Text Book-1: Chapter 1: 1.1 to 1.2)			
UNIT – II			08 Hours

Fluid Kinematics and Dynamics Lagrangian and Eulerian Approach for fluid flow, Continuity equation Velocity and acceleration in a flow field, Potential and stream function, Fluid Dynamics Introduction, Equation of motion, Euler's equation of motion, and Bernoulli's equation derived from fundamental & Euler's equation, Bernoulli's equation for real fluids. Fluid Flow measurements- Venturimeter, orifice meter and Pitot tube. Flow through Pipes-Major & Minor losses in pipe flow. Numerical exercise. of large integers, (Text Book-2: Chapter 7: 7.1 to 7.6)	
UNIT - III	06 Hours
Dimensional Analysis and Boundary Layers Introduction, Dimensional homogeneity -Buckingham theorem - Non-dimensional numbers - Model laws; Unit Quantities and Specific quantities, introduction to boundary layer theory -Laminar flow and Turbulent flow - Boundary layer thickness. (Text Book-2: Chapter 7: 7.2 to 7.3)	
UNIT - IV	09 Hours
Hydraulic Turbines Euler's Turbine equation, Classification of turbines, Impulse and reaction turbines, Pelton wheel, Francis and Kaplan turbine -work done and efficiencies. Draft tube theory, Performance of hydraulic machines, unit and specific quantities, turbine governing. The Knapsack problem (Text Book-2: Chapter 9.1: 9.6).	
UNIT - V	08 Hours
Pumps Classification, working, work done - monometric head- losses and efficiencies- specific speed- pumps in series and parallel-performance characteristic curves, NPSH. Reciprocating pumps: Working, Discharge, slip. (Text Book-2: Chapter 14: 14.1, 14.7)	
Course Outcomes: At the end of the course the student will be able to: • Categorize the fluids based on rheological behavior and also calculate the pressure, velocity and acceleration at a point in a static as well as fluid under motion • Apply Bernoulli's equation for a real fluid flowing between two sections for various engineering applications like measurement of discharge and estimation of losses • Develop non-dimensional groups for a physical phenomenon dependent on number of variables and also predict different flow regimes possible in case of a fluid -solid interaction based on critical Reynold's number • Calculate the power produced/ consumed and efficiencies obtained from a turbine/pump based on the velocity triangles • Compute the discharge, losses in a pipe flow and performance of hydraulic machines by conducting experiments	
List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs`	
1. Rotameter Calculation of the Rate of Flow Using Rotameter	
2. Venturimeter Determination of the Co- Efficient of Discharge of the Venturimeter	
3. Orifice Meter	

Determination of the Co-Efficient of Discharge of the Given Orifice Meter	
4. Pipe Friction	Determination of frictional loss in a pipe flow
5. Pipe Fittings	Determination of Loss of Head on Pipe Fittings
6. Notch	Determination of Co- efficient of Discharge of the Given Notch
7. Centrifugal Pump	Study of Performance Test On Centrifugal Pump
8. Reciprocating Pump	Study of Performance Test On Reciprocating Pump
9. Gear Pump Test Rig	Study of Performance Test On Gear Pump
10. Pelton Wheel Turbine	Study of Performance Test on Pelton Wheel Turbine
11. Francis Turbine	Study of Performance Characteristics Curves of Francis Turbine

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	1	1	1	1	1	1	1	1	2	2	3
CO2	3	3	2	2	1	1	1	1	1	1	1	2	2	3
CO3	3	2	2	1	2	1	1	1	1	2	1	2	3	3
CO4	2	3	2	2	1	1	1	1	2	2	2	2	3	3
CO5	2	2	3	3	2	1	1	1	3	3	3	3	2	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

TEXT BOOKS:

1. Jagdish Lal, Hydraulic Machines, Metropolitan Company book company Limited, 2016.
2. Yunus A.Cengel, John M.Cimbala Fluid Mechanics– Fundamental and Applications, Tata McGraw-Hill Publishing Co. Ltd, 2006.

REFERENCE BOOKS:

1. Bruce R. Munson, Donald F. Young, Theodore H. Okiishi, Wade W. Huebsc (2009)
2. Fundamentals of Fluid Mechanics, John Wiley & Sons Publications.Frank M White (2011),

E-Resources:

5. <https://open.umn.edu/opentextbooks/textbooks/85>
6. <https://library.iitd.ac.in/index.php/node/81851>
7. <https://www.constructionplacements.com/books-on-fluid-mechanics/>
8. <https://searchworks.stanford.edu/view/11842972>

<u>Machining Process and Metrology</u> [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – III	
Subject Code : 22ME2304	Credits : 03
Hours / Week : 04 Hours	Total Hours : 26+26 Hours
L-T-P-S : 2-0-2-0	
<u>Course Learning Objectives:</u> This Course will enable students to: - Understand the basic fundamentals and mechanics of metal cutting, tool geometry and life. - Explain the basic knowledge of various non-traditional machining processes - Impart knowledge on CNC machining operation - Describe and illustrate the concept of slip gauges and wringing phenomenon and Study on different types of mechanical and electrical compactors - Study the limits, fits, tolerances and gauges.	
<u>Teaching-Learning Process (General Instructions)</u> These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. - Show Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, ask at least three Higher order Thinking questions in the class. - Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. - Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I MODULE 1: Theory of Metal Cutting	05 Hours
Types of cutting tool materials, cutting fluids, Single & Multi point cutting tool nomenclature, orthogonal and oblique cutting, mechanism of chip formation, types of chip, merchant analysis, Ernst-merchant's solution, shear angle relationship, problem of merchant's analysis, tool wear and tool failure effects of cutting parameters, tool life criteria, Taylor's tool life equation, problems. . (Text Book-1: Chapter 1: 1.1 to 1.2)	
UNIT – II: Non-Traditional Machining Processes	05 Hours

Introduction, Classification, Abrasive jet machining, Ultrasonic machining, Water jet machining, Abrasive Water Jet Machining, Electro chemical machining, Electro Chemical Grinding, Electro-discharge machining, Laser beam machining, Electron Beam Machining, Chemical Milling, Photochemical Milling process characteristics – applications, advantages and disadvantages.	
UNIT – III: Computer Numerical Control & Part Programming	06 Hours
Fundamentals of numerical control, advantages & classification of NC systems, Functions of MCU, principles of operation features, functions of CNC, Manual part programming, Codes and concepts, point to point and contour programming examples, 2-D simple problems of Drilling, Turning and Milling.	
UNIT – IV: Standards of Measurement in Metrology	06 Hours
Concept of metrology, role of standards, and standards of length Principles, calibration of standards, numerical problems, and slip gauges, set of gauges, wringing phenomena, manufacture of slip gauges. Numerical problems on building of slip gauges, Errors in measuring instruments, classification of errors, sources of errors and uncertainty. Comparators - mechanical, electrical, pneumatic and optical comparators Advances in Metrology Basic concept of lasers, laser Interferometers. Basic concept of CMM, Types of CMM.	
UNIT – V : System of Limits, Fits, Tolerance and Gauging	04 Hours
Indian standards, concept of limits of size and tolerances, interchange ability, selective assembly definition of fits, hole basis system, shaft basis system, types of fits and their designation, geometric tolerance. Classification of gauges, brief concept of design of gauges (Taylor's principles), Numerical problems.	
List of Laboratory/Practical Experiments activities to be conducted : 26 Hrs	
1. To Study Construction, Working and Performing Operations on a Lathe, Drilling, Grinding & Shaping Machine	
2. To study tool wear and tool life measurements for machinability	
3. Introduction of Computer Numerical Control Machines and working of few Models on CNC machine.	
4. Calibration of Micrometer, Vernier caliper, Thermocouple, Linear Variable Differential Transformer (LVDT), Load Cell To calibrate and measure the given component by using Micrometer, Vernier caliper, Thermocouple, Linear Variable Differential Transformer (LVDT), Load Cell	
5. Measurements using Optical Profile Projector, Toolmaker's Microscope To measure the screw thread parameters of a given specimen using Optical Profile projector & Tool Maker's Microscope	
6. Measurements of angle using Sine bar & universal bevel protractor To determine the unknown angle of the given specimen using sine bar with the help of slip gauge & universal bevel protractor	
7. Measurements of Screw thread parameters using two wire or three-wire methods - To find the effective diameter of a given screw thread by two or three wire method.	
8. Measurements of gear tooth profile using gear tooth Vernier caliper - To Measure the tooth thickness of the given gear using Gear Tooth Vernier Caliper	
9. Study the mechanism and working of 3D Printing machine	

Course Outcomes:

At the end of the course the student will be able to:

- Select an appropriate machine tools for various machining operations
- Compare the non-traditional machining processes for advanced machining applications
- Illustrate working of CNC machine and perform part programming for 2D milling, and drilling operations
- Apply measurement standards and system, Comparators and Slip gauges to calculate related errors during measurements.
- Calculate tolerance, limits of size, fits, gauges and the various design concepts in gauging

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	1	1	1	1	1	2	2	2	2	3	3
C02	2	3	3	2	1	1	1	1	2	2	1	2	3	3
C03	2	2	3	2	3	1	1	1	2	2	2	2	3	3
C04	2	2	2	2	2	1	1	1	2	3	3	2	2	3
C05	2	2	2	2	2	1	1	1	2	3	3	2	2	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. P.N. Rao (2018) "Manufacturing Technology – Metal Cutting and Machine Tools," Volume-II, 4 Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi.
2. R.K. Jain (2009), Engineering Metrology, Khanna Publishers, New Delhi.

REFERENCES:

1. M. P. Groover (2019), "Fundamentals of Modern manufacturing" -materials, processes and systems Third Edition, Wiley publications, 7th Edition.
2. Kaushik Kumar, Chikesh Ranjan and Paulo Davim (2020) CNC Programming for Machining, Springer International Publishing.
3. Ernest O. Doebelin (2019), Measurement Systems: Application and Design, SIE Publications
4. Beckwith Marangoni and Lienhard (2006), Mechanical Measurements, Pearson Education, 6th Edition

E-Resources:

Activity Based Learning (Suggested Activities in Class)

3. Real world problem solving and puzzles using group discussion. E.g., Fake coin identification, Cabbage puzzle, Konigsberg bridge puzzle etc.,
4. Demonstration of solution to a problem through programming.

THERMODYNAMICS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – III	
Subject Code : 22ME2305	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Introduce basic concepts related to thermodynamic system 2. Understand Zeroth law of thermodynamics as basis for temperature measurement. Define first law of thermodynamics as applied to a closed and open systems 3. Explain working of heat engine and refrigeration cycles and to define second law of thermodynamics: Kelvin Planck and Clausius Statement. 4. Understand the property entropy through Clausius inequality 5. Understand behaviour of ideal and real gases through equation of state and compressibility factor.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours
INTRODUCTION: Basic Concepts of Thermodynamics: Introduction- Basic Concepts, Thermodynamic Equilibrium, Thermodynamic properties, Thermodynamic state, state point, path and process, quasi-static process, cyclic and non-cyclic processes, Energy and its forms, Work and heat (sign convention), Zeroth Law of Thermodynamics: Zeroth law of thermodynamics statement, Concept of Temperature and its' measurement. (Text Book-1: Chapter 1: 1.1 to 2.11)	

UNIT - II	08 Hours
First law of thermodynamics: Application to closed and open system, Joules experiments, equivalence of heat and work, Internal energy and enthalpy, energy as a property, specific heat at constant pressure and volume, PMM1, steady state, steady flow energy equation (SFEE), extension of first law to control volume, Limitations of first law of thermodynamics, Extension of SFEE to Various devices like-nozzle, turbine , pump/compressor, heat exchanger <i>(Text Book-1: Chapter 4: 4.1 to 5.4)</i>	
UNIT - III	06 Hours
Second Law of Thermodynamics: Thermal reservoirs, , devices converting work to heat in a thermodynamic cycle, heat engine, Efficiency reversed heat engine, heat pump, Refrigerator, Coefficient of Performance, Kelvin-Planck and Clausius statement of second law of thermodynamics, Equivalence of the two statements, reversible and irreversible processes, factors that make a process irreversible, Carnot cycle and Carnot engine, Carnot theorem and its corollaries. <i>(Text Book-1: Chapter 6: 6.1 to 6.18)</i>	
UNIT - IV	08 Hours
Entropy: Classius Inequality:- Statement, proof, application to a reversible cycle, Entropy: Definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility, Tds equation, calculation of entropy using TdS relations, entropy as a coordinate, Exergy(Available) and unavailable energy, Second law efficiency. <i>(Text Book-1: Chapter 7: 7.1 to 7.18)</i>	
UNIT - V	09 Hours
Pure substance: Phase change process in a pure substance, Definition of triple, ice, steam and critical points, Property diagrams of pure substance, p-v, p-T, p-h, T-v, T-s diagrams, dryness fraction, use of steam tables. <i>(Text Book-1: Chapter 9: 9.1 to 9.8)</i> Ideal and Real Gases Gas laws- Boyle's Law, Charles Law ,Gay-Lussac Law, Avogadro's law, equation of state - Vander Waals, Redlich-Kwong, Peng- Robinson etc. compressibility factor. <i>(Text Book-1: Chapter 10: 10.1 to 10.19)</i>	
Course Outcomes: At the end of the course the student will be able to: • Apply laws of thermodynamics in temperature measurement and also calculate work and heat interaction of system with the environment • Analyze closed and open system performance using second law of thermodynamics • Calculate entropy change of a system and surrounding by undergoing a thermodynamic process • Estimate the maximum work potential of energy source based on the laws laid down by thermodynamics • Calculate thermodynamic properties of a pure substance in a given state	

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	2
C02	3	3	3	3	3								2	2
C03	3	3	3	3	2								2	2
C04	3	3	3	3	2								1	1
C05	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

- P.Nag (2017), Basic & Applied Thermodynamics, 2nd Edition, Mc Graw Hill Education.
- Van Wylen, G.J., and Sonntag, R.E., (2002), Fundamentals of Classical Thermodynamics for Engineers, 6th Edition, Wiley.

REFERENCE BOOKS:

1. Yunus A Cengel and Michael A Boles (2017), Thermodynamics: An Engineering Approach, McGraw Hill Education.
- Michael J. Moran, Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd, Chichester.

E-Resources:

- <https://nptel.ac.in/courses/102106026>
- <https://www.classcentral.com/course/edx-thermodynamics-of-materials-21137>
- <https://www.askiitians.com/iit-jee-thermal-physics/introduction-to-thermodynamics/>
- <https://www.coursera.org/learn/thermodynamics-intro>

Activity Based Learning (Suggested Activities in Class)

- Use of simulations and modelling software to explore complex thermodynamic systems and see how changes in variables affect the overall behaviour of the system. For example, students could use a simulation to explore how changes in pressure and temperature affect the behaviour of a gas.
- Experiments can help students visualize and experience the concepts they are learning about in class. For example, students could conduct experiments to measure the specific heat capacity of different materials or to observe phase changes in different substances.

COMPUTER AIDED MACHINE DRAWING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	: 22ME2306	Credits	: 03
Hours / Week	: 05 Hours	Total Hours	: 65 Hours
L-T-P-S	: 1-0-0-4		

Course Learning Objectives:

The objectives of the Course are to:

1. **Provide** overview of various CAD software
2. **Learn** basics of sketching features
3. **Create** 3D models using extrude, revolve, draft & other advanced options
4. **Introduce** assembly concepts
5. **Create** simple & complex mechanical assemblies
6. **Create** industrial standard drawings with appropriate views including sectional views

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

Lecture method means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.

Interactive Teaching: Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.

- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I CAD OVERVIEW

05 Hours

CAD OVERVIEW:

Preferences-Settings, User Interface- Familiarize the User Interface by creating a simple design Familiarize The User Interface of Fusion 360 (Toolbar, Marking Menu, Browser, And Time Line Controls, Change of Workspace) Familiarize the User Interface of FUSION 360 (Navigations and data panel interface, Design Units and Origin, Quick Shape Creation) Use of toolbar, marking menu, browser and time line controls, change of workspace, Navigations and data panel interface, Design Units and Origin, Quick Shape Creation.

(Text Book-1: Chapter 1)

UNIT – II SKETCHING WORKSPACE		10 Hours
SKETCHING WORKSPACE: Sketching Workspace: Creating a sketching geometry - Introduction to the Sketching Workflow Sketch Entities, <i>(Text Book-1: Chapter 2)</i> Dimensioning, Sketch Constraints. <i>(Text Book-1: Chapter 3)</i> Additional Sketching Tools- Additional Entity Types, Editing Tools, Additional Dimension Tools, Moving and Copying, Rectangular and circular Patterns. Sketched Secondary Features using existing geometry. Pick and Place Features- Fillets, Chamfers, Holes, Editing Pick and Place Features. Construction of planes, axis and points, creating a sketch using Equation and Parameters. <i>(Text Book-1: Chapter 4)</i>		
UNIT – III SOLID MODELLING		15 Hours
SOLID MODELLING Introduction-Solid Modelling Basic Part modelling features- Extrude and revolve. Additional Features and Operations- Draft, Shell, Rib, Split Face, Scale, Thread, Press Pull. Direct Modelling Development of multi section solids and sweep. Feature Duplication – mirroring and patterning. <i>(Text Book-1: Chapter 5, 6 & 7)</i> Design and Display Manipulation- Reordering, inserting, suppressing Features, Measure and Section Analysis, Develop the part models and prepare the drafting. List out the operations involved to prepare the components. <i>(Text Book-1: Chapter 8, 9 & 10))</i>		
UNIT – IV ASSEMBLY		15 Hours
ASSEMBLY Distributed Design- Assembly Design Methods, Joint Origins and Assigning Joints. Component Design Tools- Rigid Groups, Interference Detection Multi-Body Design- Multi- Body Design Tools, Components, As-Built Joints <i>(Text Book-1: Chapter 11& 12)</i> Drawing Basics-Creating a New Drawing, Additional Drawing Views, Exploded Views, Manipulating Drawings. Detailing Drawings- Dimensions, Parts List and Balloons, Annotation and Dimension Settings, Drawing Output. Data exchange standards – IGES, STP, STL, STEP etc <i>(Text Book-1: Chapter 14))</i>		
UNIT – V MACHINE ASSEMBLY		20 Hours
MACHINE ASSEMBLY Develop the assembly drawing from the given detailed drawing (Swivel bearing) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly <i>(Text Book-2: Chapter 18: 18.5.8)</i> Develop the assembly drawing from the given detailed drawing (steam engine connecting rod end) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly <i>(Text Book-2: Chapter 19: 19.2)</i> Develop the assembly drawing from the given detailed drawing (Pressure relief valve) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly <i>(Text Book-2: Chapter 18: 18.4.8)</i>		

Develop the assembly drawing from the given detailed drawing (Machine vice) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.3.9)

Develop the assembly drawing from the given detailed drawing (Tailstock) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.3.5)

Develop the assembly drawing from the given detailed drawing (Piston of a petrol engine) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.2.6)

Develop the assembly drawing from the given detailed drawing (Air valve) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.2.10)

Develop the assembly drawing from the given detailed drawing (Fuel Injector) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.2.11)

Develop the assembly drawing from the given detailed drawing (Speed reducer) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.5.15)

Develop the assembly drawing from the given detailed drawing (Drill jig) showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly

(Text Book-2: Chapter 18: 18.3.11)

Course Outcomes:

At the end of the course the student will be able to:

- Compare the functionality of different tools and features within Fusion 360 for machine assembly requirements.
- Apply simple and advanced sketching tools and features in Fusion 360 to create precise and complex 2D sketches, considering appropriate sketch entities, dimensions, and constraints.
- Utilize design constraints and parameters in Fusion 360 to create parametric 3D models, allowing for modification and adaptation of empirical relations.
- Assess the machine assembly models in Fusion 360, identifying any potential interferences, clashes, or design issues.
- Develop precise and professional manufacturing drawings with appropriate dimensions, annotations, and GD&T symbols using Fusion 360 tools.

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	2	2	1	1	1	2	2	2	2	3	3	3
CO2	3	3	3	2	3	1	1	1	2	2	1	2	3	3	3
CO3	3	3	3	2	3	1	1	1	2	2	1	2	3	3	3
CO4	3	3	3	3	3	1	1	1	3	3	2	2	3	3	3
CO5	3	3	3	2	3	1	1	1	2	3	3	2	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXTBOOKS:

1. Autodesk Fusion 360: A Power Guide for Beginners and Intermediate Users, John Willis, Sandeep Dogra, Cadartifex. Createspace Independent Publishing Platform, USA, 2018.
2. Machine Drawing, K. L. Narayana, P. Kanniah, K. Venkata Reddy, 5th Edition, New Age International Publishers, Newdelhi, 2016.

REFERENCE BOOKS:

1. Machine Drawing in First angle projection, K. R. Gopalakrishna, Subhas publication, Bangalore, 2017.
2. Machine Drawing, N.D. Bhat & V.M.Panchal, Charotar Publishing House., 2016.

E-BOOKS / ONLINE RESOURCES/VIRTUAL LABS:

1. <https://www.gutenberg.org/ebooks/39033>

MOOC:

1. <https://www.coursera.org/learn/fusion-360-integrated-cad-cam-cae>

Activity Based Learning (Suggested Activities in Class)

1. Activity which makes students to apply the machine drawing concepts learned in the course during the drafting of 3D machine parts and its assembly using CAD tool, will be discussed in class.
2. Activity that makes the students for the development of skill set in the 3D modelling tool (Fusion 360).
3. Activity provides space to students giving responsibility for their own learning to make them into independent thinkers.
4. Activity that makes the students to have critical thinking, developing an expert mind set in Geometric dimensioning and tolerances, problem-solving and teamwork.

PROBABILITY AND STATISTICS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – IV	
Subject Code : 22ME2401	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Apply statistical principles and probability concepts to solve complex problems in real-world scenarios involving uncertainty and randomness. 2. Evaluate and select appropriate probability distributions and statistical techniques to analyze and interpret data accurately in various applications. 3. Justify the use of estimation methods and hypothesis testing techniques for drawing meaningful inferences about population parameters. 4. Analyze and interpret sample test results for different statistical relationships, such as means, variances, correlation coefficients, regression coefficients, goodness of fit, and independence, to make informed decisions. 5. Identify sample tests using appropriate statistical procedures to investigate the significance of observed data and communicate findings effectively.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Probability	09 Hours
Definitions of Probability, Addition Theorem, Conditional Probability, Multiplication Theorem, Bayes' Theorem of Probability	
UNIT – II: Random Variables and their Properties and Probability Distributions	09 Hours
Discrete Random Variable, Continuous Random Variable, Joint Probability Distributions Their Properties, Probability Distributions: Discrete Distributions: Binomial, Poisson Distributions and their Properties; Continuous Distributions: Exponential, Normal, Distributions and their Properties.	

UNIT – III: Estimation and testing of hypothesis	06 Hours
Sample, Populations, Statistic, Parameter, Sampling Distribution, Standard Error, Un-Biasedness, Efficiency, Maximum Likelihood Estimator, Notion & Interval Estimation.	
UNIT – IV: Sample Tests-1	07 Hours
Large Sample Tests Based on Normal Distribution, Small Sample Tests: Testing Equality of Means, Testing Equality of Variances, Test of Correlation Coefficient	
UNIT – V: Sample Tests-2	08 Hours
Test for Regression Coefficient; Coefficient of Association, 2 – Test for Goodness of Fit, Test for Independence.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the principles of probability to solve complex problems in various real-world scenarios.	L2 & L3
2	Solve and compare different probability distributions, including discrete and continuous random variables, in order to make informed decisions and predictions.	L2 & L3
3	Apply statistical estimation techniques, such as maximum likelihood estimation and interval estimation, to draw meaningful inferences about population parameters from sample data.	L3
4	Examine hypothesis testing methods, including large and small sample tests, to assess the significance of observed data and draw valid conclusions.	L4
5	Analyze statistical relationships and perform sample tests to assess the Equality of means in different populations, Correlation coefficients between variables to determine the strength and direction of the relationship. Independence of variables using appropriate statistical tests to assess the absence of any relationship.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	2	2		2				1					
C02	3	2	2		2				1					
C03	3	2	2						1					
C04	3	2	2		2				1					
C05	3	2	2		2				1					

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. Probability & Statistics for Engineers and Scientists, Walpole, Myers, Myers, Ye.
Pearson Education.

REFERENCE BOOKS:

3. Probability, Statistics and Random Processes T. Veerarajan Tata McGraw – Hill
4. Probability & Statistics with Reliability, Queuing and Computer Applications, Kishor S. Trivedi, Prentice Hall of India ,1999

E-Resources:

1. <https://nptel.ac.in/courses/106104233>
2. <https://nptel.ac.in/courses/117103067>
3. <https://nptel.ac.in/courses/103106120>
4. <https://www.coursera.org/learn/probability-intro#syllabus>
5. <https://nptel.ac.in/courses/111104073>

Activity Based Learning (Suggested Activities in Class)

1. Tools like Python programming, R programming can be used which helps student to develop a skill to analyze the problem and providing solution.
2. Regular Chapter wise assignments/ Activity/Case studies can help students to have critical thinking, developing an expert mind set, problem-solving and teamwork.

Following are Activities Can carried out in place of Assignments using either R programming language or Python Programming or excel solver.

1. There are n people gathered in a room. What is the probability that at least 2 of them will have the same birthday? (Use excel solver, R Programming, Python Programming)
 - a. Use simulation to estimate this for various n., and Produce Simulation Graph.
 - b. Find the smallest value of n for which the probability of a match is greater than 0.5.
 - c. Explore how the number of trials in the simulation affects the variability of our estimates.
2. **Case Study 1: Customer Arrivals at a Coffee Shop**
 - a. Background: A coffee shop wants to analyze the number of customer arrivals during its morning rush hour (7:00 AM to 9:00 AM). The shop has been recording the number of customer arrivals every 15 minutes for the past month.
 - b. Data: The data consists of the number of customer arrivals recorded at the coffee shop during each 15-minute interval for the past month.
 - c. Here is a sample of the data:

Time Interval	Customer Arrivals
7:00 AM - 7:15 AM	6
7:15 AM - 7:30 AM	4
7:30 AM - 7:45 AM	9
7:45 AM - 8:00 AM	7
8:00 AM - 8:15 AM	5
8:15 AM - 8:30 AM	8
8:30 AM - 8:45 AM	10
8:45 AM - 9:00 AM	6

analyze the customer arrivals and determine the probability distribution that best fits the data. Specifically, explore both discrete and continuous probability distributions, including the binomial, Poisson, exponential, and normal distributions.

3. Case Study 2: Comparing the Performance of Two Groups

- a. Suppose you are a data analyst working for a company that manufactures a new energy drink. The marketing team conducted a promotional campaign in two different cities (City A and City B) to determine the effectiveness of the campaign in increasing sales. The sales data for a random sample of customers in each city was collected over a week. Your task is to compare the average sales between the two cities and test whether there is a significant difference in the variance of sales.

- b. Data: Let's assume the following sample data for the number of energy drinks sold in each city:

City A: [30, 28, 32, 29, 31, 33, 34, 28, 30, 32]

City B: [25, 24, 26, 23, 22, 27, 29, 30, 26, 24]

perform a two-sample t-test to test the equality of means and a test for equality of variances using Python's SciPy library.

4. case study 3: testing independence between two categorical variables.

- a. Data: Sample of 100 employees, and each employee is classified as either Male or Female. They were asked to rate their job satisfaction on a scale of 1 to 5, where 1 represents low satisfaction and 5 represents high satisfaction. The data is as follows:

Employee	Gender	Job Satisfaction
1	Male	4
2	Female	3
3	Male	2
4	Female	5
...	...	...
100	Female	4

- b. Test for independence between gender and job satisfaction, use the chi-squared test in R.

APPLIED THERMAL SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	: 22ME2402	Credits	: 03
Hours / Week	: 05 Hours	Total Hours	: 39+26 Hours
L-T-P-S	: 3-0-2-0		

Course Learning Objectives:

This Course will enable students to:

1. **Understand** Vapour power cycles and calculation of heat, work interactions and thermal efficiency
2. **Explain** the working of a single stage and multistage compressor and to calculate work done, volumetric-isothermal-polytrophic efficiencies
3. **Understand** refrigeration cycle and calculation of COP and to study different types of refrigerants and to appreciate the use of eco-friendly refrigerants
4. **Study** combustion thermodynamics of fuels
5. **Carry out** tests to investigate the performance of internal combustion engines
6. **Describe** and illustrate the idea of Backtracking and Branch and Bound algorithm design techniques to solve a given problem.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT - I	08 Hours
Gas Power Cycles Review of thermodynamics laws, Carnot, Otto, Diesel and Dual Cycles; simple Gas turbine cycle (Brayton cycle) and Modifications; Multistage compression with intercooling, Regeneration, reheat cycles practical gas turbine, cycles; Jet Propulsion cycles (Text Book-2: Chapter 13.1: 13.22),	
UNIT - II	08 Hours
Vapour Power Cycles and Combined cycle power plants Components of steam power plant, Carnot vapour power cycles, limitation of Carnot cycle, Simple Rankine cycle; Effect of pressure and Temperature on performance of Rankine Cycle, Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, feed water heaters. Reheat Rankine cycle, Supercritical Rankine cycle, combined gas and vapour cycle power plants. Numerical (Text Book-2: Chapter 12:12.1, 12.14)	
UNIT - III	06 Hours
Reciprocating Compressors Classification; work done in a single stage compressor; efficiency; p-v diagram for an actual compressor and diagram factor; multistage compressor; Multistage compressor with intercooler, Performance parameters for reciprocating compressors (Text Book-2: Chapter 17:17.1, 17.06)	
UNIT - IV	10 Hours
Refrigeration and Air conditioning Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Vapour absorption refrigeration system. Psychometric: Nomenclature, Definition, use of Psychometric chart, Introduction to air-conditioning, different types of air-conditioning systems (Text Book-2: Chapter 14:14.1, 14.12)	
UNIT - V	08 Hours
Combustion Thermodynamics Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions. (Text Book-2: Chapter 19:19.1, 19.10)	
Course Outcomes: At the end of the course the student will be able to: - Calculate work obtained, mean effective pressure and thermal efficiency for Otto, Diesel , Dual and Bryton cycles, Thermal efficiency of Basic, modified , reheat and regenerative Rankine cycles - Calculate the work done and efficiency for single stage and multistage compressor - Analyze different refrigeration and air-conditioning cycles - Analyze combustion thermodynamics of fuels	

	- Estimate the properties of fuels and lubricants like flash and fire point, viscosity and calorific value. - Predict I C engine performance parameters at different operating conditions and also to carry out heat balance
Sl. No	List of Laboratory/Practical Experiments activities to be conducted (if any) Total 26 Hrs
1	Determination of Flash point and Fire point of lubricating oil using Abel, Pensky and Marten's (closed) / Cleveland's (Open Cup) Apparatus.
2	Determination of Calorific value of solid, liquid and gaseous fuels.
3	Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
4	Valve Timing/port opening diagram of an I.C. engine (4 stroke/2 stroke).
5	Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal Efficiencies, Volumetric efficiency, Mechanical efficiency, SFC, FP, A-F Ratio, heat balance sheet
6	Determination of temperature distribution, fin efficiency in natural / forced Convection

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	2
C02	3	3	3	3	2								2	2
C03	3	3	3	3	2								2	2
C04	3	3	3	3	2								1	1
C05	3	3	2	2	2								1	1
C06	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

- Kadambi, T. R Seetaraman and K. B Subramanya Kumar, Applications of Thermodynamics, Wiley India Private Ltd, New Delhi, 2019.
- Nag P.K Basics and applied thermodynamics, Second edition, Tata McGrawHill, New Delhi, 2017.

REFERENCE BOOKS:

- Yunus A Cengel and Michael A Boles, Thermodynamics: An Engineering Approach, McGraw Hill Education.2017
- Michael J. Moran and Howard N. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd, 2006.

E-Resources:

- <https://nptel.ac.in/courses/112103307>
- <https://archive.nptel.ac.in/courses/112/106/112106314/>
- http://gateandupscexammaterials.yolasite.com/resources/standard_books/Applied%20Thermodynamics%20by%20Onkar%20Singh.0001.
- https://onlinecourses.nptel.ac.in/noc22_me113/preview

Activity Based Learning (Suggested Activities in Class)

7. students to conduct a thermodynamic analysis of a refrigerator using the principles of thermodynamics they have learned. This will help them understand how refrigerators work and how energy is transferred in a refrigeration cycle.
 8. students to conduct experiments on the thermodynamic properties of materials, such as thermal conductivity and specific heat. This activity will help students understand how the properties of materials affect their thermodynamic behaviour.
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KINEMATICS AND DYNAMICS OF MACHINES [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – IV	
Subject Code : 22ME2403	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Impart knowledge on the kinematics and dynamics of planar mechanisms 2. Analyze the bodies which is in motion using the basics of kinetics and kinematics 3. Determine the balancing of masses of rotating and reciprocating machine elements 4. Understand the principles of cams and followers 5. Distinguish the performance of different governors by characterize effort, power and sensitiveness 6. Understand the gyroscopic principle and verifying its effect by changing the torque.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I BASICS OF MECHANISMS	07 Hours
BASICS OF MECHANISMS Definitions Link or element, kinematic pairs, chain, Mechanism and Structure, Degrees of freedom, Grubler's criterion. (Text Book-1: Chapter 1: 1.1, 1.2, 1.4, 1.5, .6, 1.7, 1.8, 1.9, 1.10, 1.11) Inversions of various mechanism. Quick return motion Mechanisms. (Text Book-1: Chapter 1: 1.12, 1.13, 1.16, 1.17, 1.18) Straight line motion mechanisms. Intermittent Motion mechanisms. Toggle mechanism, Pantograph, Steering gears mechanism. Universal Hook's Joint. (Text Book-1: Chapter 6: 6.1, 6.2, 6.4, 6.5, 6.7, 6.8,6.9)	

UNIT – II KINEMATIC ANALYSIS		07 Hours
KINEMATIC ANALYSIS Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism. <i>(Text Book-1: Chapter 2 & 3: 2.1, 2.5, 2.6, 2.7, 2.8, 2.93.1, 3.2, 3.4)</i> Relative velocity and acceleration of particles in a common link and coincident Particles on separate links- Coriolis component of acceleration. <i>(Text Book-1: Chapter 2 & 3: 2.10, 3.5, 3.6)</i> Velocity Analysis by Instantaneous Center Method. Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism. <i>(Text Book-1: Chapter 2 & 3: 2.12, 2.13, 2.14, 3.8)</i>		
UNIT – III STATIC AND DYNAMIC FORCE ANALYSIS		08 Hours
STATIC AND DYNAMIC FORCE ANALYSIS Introduction, Static equilibrium. Equilibrium of two and three force members, members with two forces and torque, free body diagrams. Principle of virtual work, static force analysis of various mechanisms with and without friction. <i>(Text Book-1: Chapter 12 : 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, 12.8, 12.9)</i> Dynamic Force Analysis: D'Alembert's principle, inertia force and torque. Dynamic force analysis of four-bar and slider crank mechanism. <i>(Text Book-1: Chapter 13 : 13.1, 13.2, 13.3, 13.4, 13.5, 13.7, 13.10)</i>		
UNIT – IV BALANCING OF ROTATING AND RECIPROCATING MASSES		07 Hours
BALANCING OF ROTATING AND RECIPROCATING MASSES Static and dynamic balancing. Balancing of single and several rotating mass. <i>(Text Book-1: Chapter 14 : 14.1, 14.2, 14.3, 14.4)</i> Balancing of single cylinder engine: multi cylinder-inline engine (primary & secondary forces), V-type engine. Balancing of locomotives <i>(Text Book-1: Chapter 14 : 14.6, 14.7, 14.8, 14.9, 14.10, 14.11)</i>		
UNIT – V CAMS, GOVERNORS, AND GYROSCOPE		10 Hours
CAMS, GOVERNORS, AND GYROSCOPE Types of cams and followers. Development of cam profile for various types of followers and its different motion. <i>(Text Book-1: Chapter 7 : 7.1, 7.2, 7.3, 7.5, 7.8, 7.9)</i> Governors: Types of governors; governor characteristics, force analysis of centrifugal governors. <i>(Text Book-1: Chapter 16 : 16.1, 16.2, 16.3, 16.4, 6.5, 16.11, 16.12, 16.13, 16.14, 16.15, 16.16, 16.17)</i> Gyroscope: Vector representation of angular motion. Gyroscopic couple, effect of gyroscopic couple on ship, plane disc, aeroplane. <i>(Text Book-1: Chapter 17 : 17.1, 17.2, 17.3, 17.4, 17.5, 17.6, 17.7)</i>		

Course Outcomes:

At the end of the course the student will be able to:

- **Analyze** and **interpret** the behaviour of kinematic mechanisms to understand their motion characteristics
- **Apply** kinematic principles and concepts to analyze the motion characteristics of mechanical systems and mechanisms.
- **Evaluate** the equilibrium of rigid bodies subjected to static and dynamic forces using appropriate
- **Utilize** appropriate balancing procedures to determine the magnitude and location of balancing masses
- **Model** cam profiles to represent their shape & motion characteristics and **estimate** the power requirements for governors & gyroscope systems based on input-output specifications.

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	2								2	2	3
CO2	3	3	3	3	2								3	3	3
CO3	3	3	3	3	3								2	2	3
CO4	3	3	3	3	2								2	2	3
CO5	3	3	3	3	2								2	2	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Theory of Machines, Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2014.

Reference Books:

1. Theory of Machines & Mechanisms, J.J. Uicker, G.R. Pennock, J.E. Shigley. Oxford University Press, 4th Edition, 2010.
2. Theory of Machines, Thomas Bevan, CBS Publication 3rd Edition, 2005.
3. Theory of Mechanisms and Machines: Amitabha Ghosh and Ashok kumar Mallik, 3rd Edition Affiliated East-West Press.1976.

E-Books / Online Resources/VIRTUAL LABS:

1. <https://mm-nitk.vlabs.ac.in/>

MOOC:

1. <https://nptel.ac.in/courses/112105268>
2. <https://archive.nptel.ac.in/courses/112/104/112104114/#>

Activity Based Learning (Suggested Activities in Class)

1. Activity which makes students to apply the concepts learned in the course to the development of mechanism based on the real time applications will be discussed in class.
2. Activity that makes the students for the development of skill set in analysis of mechanisms.
3. Activity provides space to students giving responsibility for their own learning to make them into independent thinkers.
4. Activity that makes the students to have critical thinking, developing an expert mind set, problem-solving and teamwork.

MECHANICS OF SOLIDS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	: 22ME2404	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-S	: 3-0-0-0		

Course Learning Objectives:

This Course will enable students to:

1. **Explain** about the analysis of stresses and strains in straight, Stepped and tapered sections, Composite sections under axial, shear & thermal loading conditions.
2. **Describe** the evaluation of compound stresses and strains in a structural member using analytical & Mohr's circle method. And
3. **Determine** the circumferential and longitudinal stresses in thin and thick cylindrical pressure vessels.
4. **Describe** about the construction of shear force and bending moment diagrams for cantilever, simply supported and overhanging beams subjected to concentrated loads, uniformly distributed loads, moments and uniformly varying loads.
5. **Calculate** the shear stress due to torsion in tapered shaft, Shafts in series and Parallel, Thin Tubular and Thin-walled sections. And
6. **Explain** how to use Euler's Theory of Columns to calculate the buckling load of the columns with pinned ends, both ends are fixed, one end fixed & other is free and one end fixed & other is hinged.
7. **Describe** about computation of strain energy due to axial, shear, bending & torsional stresses.
8. **Clarify** how to use Theories of Failure to determine the factor of safety when it is subjected to combined stresses.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt the Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I Analysis of Stress and Strain	08 Hours
INTRODUCTION: Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them. Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change. (Text Book-1: Chapter 2: 2.3 to 2.11)	
UNIT – II Compound Stresses and Cylinders	08 Hours
Compound Stresses: Principal stresses and maximum shear stress, Planes of Principal stress and Maximum Shear stress, Normal stress on the planes of maximum shear stress, Mohr's circle for plane stress conditions. (Text Book-3: Chapter 3: 3.4, 3.5) Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, thin spherical Shell, thin cylinder with spherical ends. Thick cylinders: Lamé's theory. (Text Book-2: Chapter 17: 17.4,17.5,17.10)	
UNIT – III Shear Forces and Bending Moments	06 Hours
Shear Forces and Bending Moments: Type of beams, Loads and reactions, Relationship between loads, Shear force and bending moments of cantilever, simply supported and overhanging beams subjected to concentrated loads and uniformly distributed constant / varying loads. (Text Book-2: Chapter 6: 6.3 to 6.18) Stress in Beams: Bending Theory, Bending and shear stress distribution in rectangular, I and T section beams. (Text Book-2: Chapter 7: 7.2 to 7.4)	
UNIT – IV Torsion and Columns	09 Hours
Torsion: Circular shafts, Power Transmission, Torsion of tapered shaft, Shafts in series and Parallel, Thin Tubular and Thin-walled sections. (Text Book-1: Chapter 3: 3.3, 3.13). Columns: Euler's theory, Equivalent Length, Limitations of Euler's Formula, Rankine's Formula (Text Book-2: Chapter 19: 19.3 to 19.10).	
UNIT – V Strain Energy and Theories of Failure	08 Hours
Strain Energy: Strain energy due to axial, shear, bending, torsion and impact load, Castigliano's theorem and their applications. (Text Book-1: Chapter 11: 11.2 to 11.12) Theories of Failure: Introduction, maximum principal stress theory (Rankine's theory), Maximum shearing stress theory (Guest's and Tresca's theory), maximum principal strain theory (St. Venant's theory), Maximum Strain energy theory (Haigh's Theory) and Maximum Shear Strain Energy Theory (Mises' and Henkeys's Theory) (Text Book-2: Chapter 04: 4.1 to 4.4)	
Course Outcomes: At the end of the course the student will be able to:	

- **Calculate** stress and strain for different geometries under different loading conditions
- **Solve** for principal stresses, maximum shearing stress acting on a structural member using analytical and Mohr's circle methods
- **Calculate** the stresses and strains associated with thin and thick cylindrical pressure vessels under axial and circumferential loads
- **Construct** shear force and bending moment diagrams for statically determinate beams
- **Calculate** the shear stress for bodies subjected to torsion and bending stresses for columns
- **Select** appropriate failure theory to calculate the safe dimensions of components and structures

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
C01	3	3	3	3	3								2	2	3
C02	3	3	3	3	2								3	3	3
C03	3	3	3	3	2								2	2	3
C04	3	3	3	3	3								2	2	3
C05	3	3	3	3	2								2	2	3
C06	3	3	3	3	2								1	1	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. F. P. Beer and E. R. Johnston (2020), Mechanics of Materials, 8th Edition, McGraw Hill publications.
2. S. S. Bhavikatti (2017), Mechanics of Solids, New Age International Publications.

REFERENCE BOOKS:

1. Stephen Timoshenko (2002), Strength of Materials, 3rd Edition, CBS Publisher.
2. Strength Of Materials, 16/e Paperback – 1 January 2011
3. Ramamrutham S, Dhanpat Rai Publishing Company (p) Ltd (1 January 2011)

E-Resources:

17. <https://archive.nptel.ac.in/courses/105/105/105105108/>
18. https://onlinecourses.nptel.ac.in/noc22_ce46/preview
19. <https://www.youtube.com/watch?v=LIZ-PQbGZkA>

Activity Based Learning (Suggested Activities in Class)

9. Real world problem solving and puzzles using group discussion.
10. Demonstration of solution to a problem through experiential learning.
11. Demonstrations using real objects, taking students on an educational tour.

HEAT TRANSFER	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – IV	
Subject Code : 22ME2405	Credits : 04
Hours / Week : 04 Hours	Total Hours : 39+26 Hours
L-T-P-S : 3-0-2-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Understand the basic phenomenon of heat transfer and its importance in engineering applications. 2. Enable the students to understand the different modes of heat transfer like conduction, convection and radiation. 3. Understand the mechanism of heat transfer under steady and transient conditions 4. Illustrate the applications of convective heat transfer including heat exchangers, boiling & condensation 5. Understand the different laws of radiation and applying for solving engineering problems	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	05 Hours
Modes of heat transfer: Basic laws governing conduction, Thermal conductivity. Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, discussion on 3-D conduction in cylindrical and spherical coordinate system. One dimensional conduction equations for plane, cylinder and spheres. Overall heat transfer coefficient, Thermal conductive resistance and numerical problems. Derivation for	

heat flow and temperature distribution in a plane for variable thermal conductivity case, critical thickness of insulation and numerical problems. (Text Book2: Chapter 1: 1.1, 1.6)	
UNIT - II	05 Hours
Heat transfer through rectangular fin , infinitely long fin, short fin with insulated tip and without insulated tips. FIN efficiency and effectiveness. Numerical problems. (Text Book 1: Chapter 3: 3.1, 3.8) Transient Conduction : Lumped parameter analysis, use of transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, numerical problems (Text Book1: Chapter 4: 4.1, 4.7)	
UNIT - III	05 Hours
Natural Convection : Introduction, laminar flow, momentum and energy equations for vertical flat plate, physical significance of Grashoff number, use of correlations for free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, numerical problems. (Text Book1: Chapter 6: 6.1, 6.7) Forced Convection : Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems. (Text Book1: Chapter 9: 9.1, 9.7)	
UNIT - IV	06 Hours
Fundamental concepts of radiation , different laws governing radiation heat transfer, Stefan Boltzman law, Kirchoff's law, Planck's law, Wein's displacement law, Intensity of radiation and Lambert's cosine law, Radiation shape factor, Heat exchange by radiation between two black and diffuse grey surfaces, radiation shields, numerical problems. (Text Book1: Chapter 12: 12.1, 12.11)	
UNIT - V	05 Hours
Heat exchangers : Classification and applications, overall heat transfer coefficient, heat exchanger analysis-Logarithmic mean temperature difference for parallel and counter flow heat exchanger, effectiveness-number of transfer units, method for parallel and counter flow heat exchanger, introduction to cross flow heat exchanger, Logarithmic mean temperature difference correction factor. Numerical problems. (Text Book1: Chapter 11: 11.1, 11.08) Condensation and Boiling : Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation. (no numerical problems). (Text Book1: Chapter 10: 10.1, 10.11)	
Course Outcomes: At the end of the course the student will be able to: • Compute temperature distribution and heat flow in steady-state and unsteady-state 1-D heat conduction • Calculate forced and free convective heat transfer coefficient and rate of heat transfer • Analyze performance characteristics of heat exchangers • Calculate radiation heat transfer between objects with simple geometries • Demonstrate conduction, convection, and radiation heat transfer phenomena through experiments	

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	2
C02	3	3	3	3	2								2	2
C03	3	3	3	3	2								2	2
C04	3	3	3	3	2								1	1
C05	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Sl. No	List of Laboratory/Practical Experiments activities to be conducted (if any)	Total 26 Hrs
1	Determination of thermal conductivity of metal rod.	
2	Determination of thermal conductivity of composite wall.	
3	Experiment on transient conduction heat transfer	
4	Determination of heat transfer coefficient in natural convection.	
5	Determination of heat transfer coefficient in forced convection.	
6	Determination of temperature distribution, fin efficiency in natural / forced Convection	
7	Determination of emissivity of a test surface.	
8	Determination of the emissive power of black body using Stefan's Boltzmann's constant	
9	Determination of effectiveness and logarithmic mean temperature difference in parallel flow and counter flow heat exchanger	

TEXT BOOKS:

1. Incropera, F.P. and DeWitt, D.P "Fundamentals of Heat and Mass transfer, John Wiley, 2011.
2. . J P Holaman Heat Transfer, Tata McGraw-Hill, 2009.

REFERENCE BOOKS:

1. P K Nag Heat and Mass Transfer, Tata McGraw-Hill, 2011.
2. Ozisik, Heat Transfer-A Basic Approach, 2002.

E-Resources:

1. <https://archive.nptel.ac.in/courses/103/105/103105140/>
2. <http://ecoursesonline.iasri.res.in/course/view.php?id=625>
3. <http://ecoursesonline.iasri.res.in/course/view.php?id=61>
4. <http://krunalkhiraiya.weebly.com/e-course-on-heat-transfer.html>

Activity Based Learning (Suggested Activities in Class)

1. Conduct a thermal conductivity experiment: Provide students with materials such as different types of metals
2. Investigate the effects of insulation: Provide students with materials such as Styrofoam, cotton, and wool, and have them investigate the effects of insulation on heat transfer by measuring the rate of heat loss from a hot object that is wrapped in each material

MACHINE LEARNING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – IV	
Subject Code : 22ME2406	Credits : 02
Hours / Week : 04 Hours	Total Hours : 13+26 Hours
L-T-P-S : 1-0-2-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Realize Machine Learning techniques in supervised and unsupervised learning. 2. Comprehend the ideas of ML and problem-solving techniques. 3. Use of Python Programming for different applications 4. Demonstrate the representation of knowledge and reasoning 5. Recognize the importance of ML in Mechanical Engineering	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours
Introduction to Python, Basics: Basic types, variables, Decision making and Loops, Strings, Data Structures: Lists, Tuples, Sets, and Dictionaries Regular Expression Operations, Modules. Object oriented programming in python: Classes, Constructors, and Object Methods. (Text Book-1: Chapter 5: 5.1 to 5.3, Chapter 6: 6.3 to 6.4, Chapter 7: 7.2 to 7.3)	
UNIT – II	
NumPy - Overview, NumPy Array creation and basic operations, NumPy Universal functions, Selecting and retrieving Data, Data Slicing. Pandas - Overview, Object Creation: Series Object, Data Frame Object, View Data, selecting data by Label and Position, Data Slicing, Setting Data, applying functions to data, Analysing Data for missing values.	

Matplotlib - Overview, creating basic chart: Line Chart, Bar Charts and Pie Charts, Plotting from Pandas object, Saving a plot. **(Text Book-1: Chapter 8: 8.4).**

UNIT - III		06 Hours
INTRODUCTION: Introduction to Supervised learning, Linear Regression Logistic Regression, Naive Bayes, Decision Tree, KNN, Random Forest, Support VectorMachine Introduction to Unsupervised learning, PCA, clustering approaches: K-means, Hierarchical clustering Natural Language Processing: Language models, n-grams, Vector space models, Bag of words. <i>(Text Book-1: Chapter 1: 1.1 to 1.2)</i>		
UNIT - IV		08 Hours
Neural Network basics: History behind neural networks, Relationship between biological neuron and artificial neuron, Perceptron and working mechanism, Architecture of artificial neuralnetwork, Types of activation functions. <i>(Text Book-1: Chapter 3: 3.1, 3.2)</i>		
UNIT - V		08 Hours
Machine learning application using python for mechanical engineering datasets: mechanical vibrations - heat transfer - fluid mechanics – manufacturing process. Smart Manufacturing, Smart Transportation and Autonomous Vehicles. Robotics, Quality control. <i>(Text Book-1: Chapter 12: 12.2, 12.3)</i>		
Course Outcomes: At the end of the course the student will be able to: • Apply Python Programming for solving engineering problems • Demonstrate the representation of knowledge and reasoning • Develop the ideas of AI and problem-solving techniques • Demonstrate Machine Learning techniques in supervised and unsupervised learning • Employ data science, AI & ML techniques in solving in Mechanical Engineering		

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	3	3								2	1
C02	3	3	3	3	3								1	1
C03	3	3	3	3	3								2	2
C04	3	3	3	3	3								2	2
C05	3	3	3	3	3								2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. Nagy Z. Artificial Intelligence and Machine Learning Fundamentals: Develop real-world applications powered by the latest AI advances. Packt Publishing Ltd; 2018.
2. Sebastian Raschka and Vahid Mir Jalili, Python Machine Learning, Second Edition: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow Paperback – September 20, 2017

REFERENCE BOOKS:

1. David L. Poole, Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
2. Nils J. Nilsson, the Quest for Artificial Intelligence, Cambridge University Press, 2009.

E-Resources:

1. <https://nptel.ac.in/courses/106/101/106101060/>
2. <http://cse01-iiith.vlabs.ac.in/>
3. <http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms>
4. <https://www.coursera.org/specializations/algorithms> .

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion. E.g., Fake coin identification, Cabbage puzzle, Konigsberg bridge puzzle etc.,
2. Demonstration of solution to a problem through programming.

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MICROPROCESSORS AND MICROCONTROLLERS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand Fundamental Concepts: Acquire a thorough understanding of microprocessor and microcontroller architectures and operations. 2. Develop Programming Skills: Learn to program and debug microprocessors and microcontrollers using assembly and high-level languages. 3. Design and Integration Skills: Master the integration of microcontrollers with mechanical components and systems. 4. Apply Real-World Technologies: Explore real-world applications, focusing on microcontroller roles in mechanical systems and IoT. 5. Enhance Problem-Solving Abilities: Enhance analytical and problem-solving skills through practical case studies and design challenges.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction to Microprocessors and Microcontrollers	09 Hours
Overview of Microprocessors and Microcontrollers: Differences and applications. History and Evolution: Key developments in microprocessor technology. Basic Architecture: CPU, memory, input/output, buses. Types of Microcontrollers: Comparison of 8-bit, 16-bit, and 32-bit microcontrollers.	
UNIT – II: Microprocessor Architecture and Programming	09 Hours
CPU Architecture: Registers, ALU, CU. Instruction Set: Types of instructions (data movement, arithmetic, control). Assembly Language Basics: Syntax, operations, and simple programming. Programming Model: Flags, stacks, interrupts, subroutine calls.	

UNIT – III: Microcontroller Hardware and Peripherals	06 Hours
Microcontroller Components: Clock system, timers, counters, watchdog timer. Input/Output Devices: GPIOs, ADC, DAC, PWM. Communication Protocols: SPI, I2C, UART, CAN. Interfacing Techniques: Sensors and actuators relevant to mechanical systems.	
UNIT – IV: System Design and Integration	07 Hours
Design Methodologies: From specifications to prototype. Embedded System Design: Integrating microcontrollers with mechanical components. Power Management: Considerations for energy-efficient design. Case Studies: Analysis of real-world mechanical applications using microcontrollers.	
UNIT – V: Advanced Topics and Applications	08 Hours
Real-Time Operating Systems (RTOS): Concepts and applicability. Internet of Things (IoT) and Connectivity: Role of microcontrollers in IoT for mechanical applications. Fault Tolerance and Safety: Ensuring reliability and safety in mechanical systems. Emerging Technologies: Overview of advancements like AI and ML integration with microcontrollers.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply microcontroller architecture knowledge to design and develop task-specific embedded systems in mechanical contexts.	L3
2	Analyze and optimize embedded system designs for efficiency and effectiveness in mechanical engineering applications.	L3
3	Evaluate and select optimal communication protocols for integrating microcontrollers with mechanical systems.	L4
4	Implement necessary fault tolerance and safety features in microcontroller-based mechanical systems.	L4
5	Integrate emerging technologies like IoT and AI to enhance the capabilities of microcontroller-driven mechanical systems.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	2	1	1	2	2	2	1	3	2
CO2	2	3	2	-	-	2	1	1	1	2	2	1	2	3
CO3	2	2	3	-	-	2	1	1	2	2	2	1	3	2
CO4	3	2	3	-	-	2	1	1	2	2	2	1	2	2
CO5	2	2	3	-	-	2	1	1	2	2	2	1	3	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbook:

1. Mazidi, M. A. (2007). The 8051 Microcontroller And Embedded Systems Using Assembly And C, 2/E. Pearson Education India.
2. Brey, B. B. (2009). The Intel microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium Pro processor, Pentium II, Pentium III, Pentium 4, and Core2 with 64-bit extensions: architecture, programming, and interfacing.

Reference books:

1. Simon, D. E. (1999). An embedded software primer (Vol. 1). Addison-Wesley Professional.
2. Catsoulis, J. (2005). Designing Embedded Hardware: Create New Computers and Devices. " O'Reilly Media, Inc."

CLOUD COMPUTING & DATA PROCESSING [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Gain a foundational understanding of data analytics, artificial intelligence, and cloud computing, focusing on their impact on mechanical engineering. 2. Acquire skills in developing and implementing AI models for mechanical engineering applications using tools like TensorFlow and PyTorch. 3. Learn to manage, process, and analyze large datasets with advanced data management tools and techniques, ensuring data integrity and security. 4. Understand and apply cloud computing solutions to enhance AI-driven data processing and analytics in mechanical engineering projects. 5. Utilize knowledge of AI, data analytics, and cloud technologies to innovate and improve mechanical systems design, maintenance, and manufacturing processes.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I: Introduction to Data Analytics and AI	09 Hours
Basics of Data Analytics: Key concepts, importance, and roles in mechanical engineering. Introduction to Artificial Intelligence: Understanding AI, its components like machine learning, deep learning, and their relevance to engineering. AI in Engineering: Examples of AI applications in mechanical systems, design, and manufacturing.	
UNIT – II: AI Techniques for Engineering	09 Hours
Machine Learning Models: Supervised and unsupervised learning techniques applied to mechanical engineering data. Deep Learning Fundamentals: Introduction to neural networks,	

CNNs, and RNNs tailored for complex engineering problems. AI Tools and Libraries: Practical sessions on using AI libraries such as TensorFlow, PyTorch in engineering applications.	
UNIT – III: Data Management and Advanced Analytics	06 Hours
Big Data Technologies: Using platforms like Hadoop and Spark for handling large-scale engineering data. Advanced Analytics Methods: Integrating predictive and prescriptive analytics to optimize mechanical operations and designs. Data Privacy and Security: Best practices for handling sensitive engineering data, focusing on regulatory and ethical considerations.	
UNIT – IV: Cloud Computing and AI Integration	07 Hours
Cloud Service Models for AI: How IaaS, PaaS, SaaS can be leveraged for AI-driven engineering tasks. Cloud-Based AI Tools: Utilization of cloud platforms for deploying and managing AI models, including AWS SageMaker, Google AI Platform. IoT and Cloud AI: Integrating IoT devices with cloud-based AI for smarter data analytics in real-time applications.	
UNIT – V: Real-World Applications and Case Studies	08 Hours
Predictive Maintenance using AI: Employing machine learning models to predict equipment failures and schedule maintenance. AI in Smart Manufacturing: Case studies on the use of AI and IoT in automating and optimizing manufacturing processes. Innovations in AI for Mechanical Engineering: Exploration of cutting-edge AI applications like autonomous robotic systems, additive manufacturing, and dynamic system simulations.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply analytical techniques to solve complex problems in mechanical engineering using data analytics and AI tools.	L3
2	Design and implement AI models using current technologies to optimize mechanical system performance.	L4
3	Evaluate and select appropriate cloud-based solutions for data-intensive mechanical engineering applications.	L3
4	Integrate and manage IoT devices with cloud computing and AI to enhance real-time data processing and decision-making.	L3
5	Demonstrate proficiency in using advanced data analytics to predict maintenance needs and improve manufacturing processes.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	2	-	2	1	1	2	2	1	1	3	2
C02	3	3	3	2	-	1	1	1	2	2	1	1	3	2
C03	2	2	2	1	-	1	1	1	2	2	1	1	2	3
C04	2	2	3	2	-	1	1	1	2	2	1	1	3	3
C05	3	3	3	2	-	2	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Mitchell, M. (2019). Artificial intelligence: A guide for thinking humans. Penguin UK.
2. Dean, J. (2014). Big data, data mining, and machine learning: value creation for business leaders and practitioners. John Wiley & Sons.

References:

1. Shukla, N., & Fricklas, K. (2018). Machine learning with TensorFlow. Greenwich: Manning.
2. Erl, T., Puttini, R., & Mahmood, Z. (2013). Cloud computing: concepts, technology & architecture. Pearson Education.

DESIGN OF MACHINE ELEMENTS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	04
Hours / Week	:	04 Hours	Total Hours	:	26+26 Hours
L-T-P-S	:	2-1-2-0			

Course Learning Objectives:

This course will enable students to:

1. Understand the stresses in machine members due to various types of loads and failure of components according to theories of failures.
2. Analyze the components under variable loading for infinite and finite life.
3. Design of machine elements under torsion, bending, axial loads and a combination of these.
4. Design of permanent and temporary joints and fasteners for a given load to be transmitted. Design of various screws, keys, coupling and shafts.
5. To understand use of different types of springs and determine safe design of spring under static and fluctuating loading conditions.
6. To understand the standard nomenclature, forces, failures, application, design procedure of Spur and Helical gears (As per AGMA)
7. To understand the standard nomenclature, forces, failures, application, design procedure of Bevel and Worm gears (As per AGMA) and to determine standard geometry under given loading condition
8. To understand the design procedure, failures and application of Ball Bearings and Sliding contact bearing
9. Design the clutches and brakes required for power transmission.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analyzing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

- Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding. Practical experimentation of curved beam, journal bearing, shaft and gears	
UNIT - I	08 Hours
Normal, shear, biaxial and triaxial stresses, factor of safety, stress concentration factor in tension, bending and torsion, theories of failures, static strength: static loads, impact strength: introduction, impact stresses due to axial, bending and torsional loads, Failure of brittle and ductile materials (text book-1: chapter 3: 3.10 to 3.13, chapter 5: 5.1 to 5.10) Introduction, S-N diagram, low cycle fatigue, high cycle fatigue, endurance limit, modifying factors: size effect, surface effect, stress concentration effects, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage. (Text Book-1: Chapter 6: 6.1 to 6.8)	
UNIT - II	08 Hours
Threaded fasteners: stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints. (Text Book-1: Chapter 8: 8.1 to 8.12) Riveted and welded joints: types, rivet materials, failures of Riveted joints, joint efficiency, boiler joints, riveted brackets. Welded joints: types, strength of butt and fillet welds, eccentrically loaded welded joints. (Text Book-1: Chapter 9: 9.1 to 9.8)	
UNIT - III	08 Hours
Joints: Types of keys, design of socket-spigot cotter joint, design of knuckle joint. Couplings: Types of couplings, design of flange and flexible couplings and muff coupling (Text Book-1: Chapter 8: 8.1 to 8.12) Shafts: torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under fluctuating loads and combined loads. Curved beams: stresses in curved beams of standard cross sections used in crane hook (Text Book-1: Chapter 7: 7.1 to 7.8)	
UNIT - IV	10 Hours
Springs: types, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, springs under fluctuating loads. Leaf springs: stresses in leaf springs. Equalized stresses, energy stored in springs, torsion. (Text Book-1: Chapter 10: 10.1 to 10.13) Gears: Spur gears, Helical gears, Bevel Gears and Worm Gears: Definitions, stresses in gear tooth: Lewis's equation and form factor, design based on strength, dynamic and wear loads, formative number of teeth, formative number of teeth, efficiency of worm gear drives (Text Book-1: Chapter 13: 13.1 to 13.11)	
UNIT - V	08 Hours
Bearings: lubricants and their properties, mechanisms of lubrication bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, heat dissipated, bearing materials, examples of journal bearing and thrust bearing design. (Text Book-1: Chapter 12: 12.1 to 12.15) Clutches & Brakes: Design of clutches: Single plate, multi plate and cone clutches. Design of Brakes: Block and band brakes: Self-locking of brakes: Heat generation in brakes. (Text Book-1: Chapter 16: 16.1 to 16.10)	
LIST OF LABORATORY/PRACTICAL EXPERIMENTS ACTIVITIES TO BE CONDUCTED: 28 HRS	
Determination of principal stresses and strains in a member subjected to combined Loading using strain rosettes and verification using FEA tool.	

2. Determination of critical speed of a rotating shaft and verification using FEA tool.
3. Determination of stresses in curved beam using strain gauge and verification using FEA tool.
4. Design of shafts subjected to direct and combined loading for given loads and conditions and comparing design by using CAD/CAE software.
5. Determination of pressure distribution in journal bearing
6. Modelling and stress analysis of spur and helical gear tooth by using CAD/CAE software
7. Modelling and stress analysis of helical and leaf springs using CAD/CAE software
8. Modelling and stress analysis of brake by using CAD/CAE software
9. Modelling and stress analysis of single plate and multi-plate clutches by using CAD/CAE software

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Classify various stresses acting on a machine element and compute the dimensions of component based on the concepts of failure theories	L3												
2	Quantify factor of safety, failure modes for mechanical components subjected to direct and bending and combined loading	L4												
3	Analyze the design of threaded fasteners, riveted joints and welding joints and calculate the strength of butt and fillet welds	L3												
4	Choose the appropriate keys, coupling, shafts and joints in the design of machine components. Classify different kinds of springs, gears, bearings, clutches and brakes and Compute tooth strength for spur, helical, bevel and worm gears	L3												
5	Interpret the pressure distribution in a journal bearing and select suitable clutch plate and brake shoe for a given application	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	2	3	-	3	2	1	1	2	2	2	1	3	2
C02	3	3	2	-	3	2	1	1	2	2	2	1	3	2
C03	3	2	3	-	3	2	1	1	2	2	2	1	3	2
C04	3	3	3	-	3	2	1	1	2	2	2	1	3	3
C05	2	3	2	-	3	1	1	1	2	2	2	1	3	2
C06	3	2	3	-	3	2	1	1	2	2	2	1	3	2

TEXT BOOKS:

1. Shigley, J. E., Mitchell, L. D., & Saunders, H. (1985). Mechanical engineering design.
2. Bhandari, V. B. (2010). Design of machine elements. Tata McGraw-Hill Education.

REFERENCE BOOKS:

1. Norton, R. L. (2010). Machine design. London, UK: Prentice Hall.
2. M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayram and C. V. Venkatesh (2019) Design of Machine Elements Pearson Education, Eighth edition.

E-Resources:

1. <https://nptel.ac.in/courses/112/105/112105124/>
2. <https://nptel.ac.in/courses/112/106/112106137/>

INTRODUCTION TO AUTOMATION AND ROBOTICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	04 Hours	Total Hours	:	26+26 Hours
L-T-P-S	:	2-0-2-0			

Course Learning Objectives:

This Course will enable students to:

1. Gain a comprehensive understanding of the fundamental concepts, history, and applications of robotics and automation in various industries.
2. Acquire knowledge and skills in the mechanical design of robotic systems, including kinematics, dynamics, and the selection of actuators and end-effectors.
3. Learn to program and interface robots using popular robotics programming languages and software, such as Python and ROS.
4. Understand the role and function of programmable logic controllers (PLCs) and how they integrate with robotic systems for enhanced automation solutions.
5. Study advanced applications and emerging trends in robotics, such as collaborative and mobile robotics, and assess their future impact on mechanical engineering.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I Introduction to Automation and Robotics		08 Hours
Overview of automation and robotics in industry; history and evolution of robotic systems; types of robots and their applications.		
UNIT – II Mechanical Design of Robotic Systems		08 Hours
Design principles of robotic systems; kinematics and dynamics of robots; end-effectors and actuators.		
UNIT – III Robotics Programming and Interfaces		06 Hours
Introduction to programming languages for robots (e.g., Python, ROS); interfacing with sensors and actuators.		
UNIT – IV Automation Technologies		10 Hours
Overview of automation technologies; PLCs and their role in automation; integration of robotic systems with manufacturing processes.		
UNIT – V Advanced Applications and Emerging Trends		08 Hours
Advanced robotic applications (collaborative robots, mobile robots); emerging trends in robotics and future implications for mechanical engineering.		
Sl. No	List of Laboratory/Practical Experiments activities to be conducted (if any)	
	Total 26 Hrs	
1	Basic safety training; introduction to robotic simulation software; simple tasks using robotic arms in simulation.	
2	Design and simulation of a robotic arm; calculation of degrees of freedom and range of motion; hands-on assembly of small robotic kits.	
3	Programming a robotic arm to perform specific tasks; sensor integration and basic task automation.	
4	PLC programming basics; creating control logic for automated sequences; interfacing PLCs with robotic arms.	
5	Experimentation with collaborative robots; introduction to mobile robotics and navigation algorithms; project presentations on innovative robotic solutions.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply fundamental robotics principles to design, analyze, and improve automation systems in mechanical engineering contexts.	L3
2	Demonstrate proficiency in programming and interfacing robotic systems for task-specific applications using industry-standard software.	L4
3	Integrate sensors, actuators, and controllers to develop comprehensive robotic systems that meet engineering specifications.	L3
4	Implement PLC programming and control logic to automate processes within robotic systems efficiently.	L3
5	Evaluate and adopt emerging robotic technologies, such as collaborative and mobile robots, for innovative mechanical engineering solutions.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	3	2	1	1	2	2	2	1	3	2
C02	3	3	2	-	3	1	1	1	2	2	1	1	3	3
C03	3	2	3	-	3	2	1	1	2	2	2	1	3	3
C04	3	3	3	-	3	1	1	1	2	2	1	1	3	2
C05	3	2	3	-	3	2	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. John J. Craig. (2017) Introduction to Robotics: Mechanics and Control by Pearson, 4th Edition,.
2. Corke, P. (2021). Robotics and control: fundamental algorithms in MATLAB® (Vol. 141). springer Nature.

Reference Books:

1. Mikell P. Groover (2014) "Automation, Production Systems, and Computer-Integrated Manufacturing" by, Prentice Hall, 4th Edition.
2. Corke, P. (2021). Robotics and control: fundamental algorithms in MATLAB® (Vol. 141). springer Nature.

THERMAL MANAGEMENT OF ELECTRONIC DEVICES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	04 Hours	Total Hours	:	26+26 Hours
L-T-P-S	:	2-0-2-0			

Course Learning Objectives:

This course will enable students to:

1. Appreciate the importance of thermal management for the performance and reliability of electronic devices
2. Identify how temperature impacts failure modes and component lifespan in electronic systems.
3. Utilize conduction, convection, and radiation principles in designing thermal management solutions
4. Evaluate and select appropriate cooling methods based on performance requirements and cost-effectiveness.
5. Apply simulations to optimize cooling strategies, predict temperature distributions, and evaluate thermal management effectiveness

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I	05 Hours
INTRODUCTION TO THERMAL MANAGEMENT: Understanding the critical role of thermal management in electronics, its impact on performance, reliability, and overall system lifespan. Overview of economic and operational consequences of thermal issues. TEMPERATURE EFFECTS ON FAILURE MODES: Exploration of how temperature affects failure mechanisms like thermal stress, fatigue, electromigration, and material expansion in electronic components.	
UNIT - II	05 Hours
CONDUCTION COOLING AND HEAT SINKS Study of materials and thermal interface materials (TIMs) used to enhance heat conduction in electronic systems HEAT SINK DESIGN: Core principles of heat sink design, including material choice, geometry, and surface treatments. examination of advanced configurations like pin-fin and vapor chamber heat sinks. CONVECTION COOLING: Overview of natural and forced convection cooling methods, focusing on fan selection, placement, and optimization for effective airflow management.	
UNIT - III	06 Hours
LIQUID COOLING TECHNIQUES Introduction to liquid immersion cooling, its principles, and the selection of appropriate dielectric fluids for high-performance applications, Flow-Through Cooling for Circuit Card Assemblies (CCAs) COLD WALL COOLING AND COLD PLATES: Exploration of cold wall cooling and cold plate designs, their applications, and integration into electronic systems for enhanced heat dissipation.	
UNIT - IV	05 Hours
ADVANCED AND EMERGING COOLING TECHNOLOGIES Principles and applications of jet impingement and synthetic jet cooling, focusing on their use for localized, high-efficiency cooling. Thermoelectric (Solid-State) Coolers COOLING USING PHASE CHANGE MATERIALS (PCM): Use of phase change materials in thermal management, including selection criteria and integration techniques.	
UNIT - V	05 Hours
MICRO/MINI CHANNEL COOLING: Applications of micro/mini channel cooling technologies in high-density and high-power electronics. HEAT PIPES: Study of heat pipe principles, working fluids, and their integration into thermal management systems for efficient heat transfer.	
LIST OF LABORATORY/PRACTICAL EXPERIMENTS ACTIVITIES TO BE CONDUCTED (IF ANY)	
TOTAL 26 HRS	
1. Simulate heat conduction through different materials and geometries using MATLAB, Study the effect of material properties (thermal conductivity) and boundary conditions on temperature distribution 2. CFD Analysis of Forced Convection Cooling: Analyze fluid flow and heat transfer in electronic cooling applications using CFD software (e.g., ANSYS Fluent) 3. Liquid Cooling System Simulation using Matlab and CFD: Develop a thermal model of a liquid cooling loop incorporating components like pumps, heat exchangers, and flow control valves using Matlab.	

4. Heat Pipe Simulation and Analysis: Simulate heat transfer in a heat pipe and analyze its effectiveness in thermal management.

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Apply the fundamental concepts of thermal management to assess their impact on the performance and reliability of electronic devices	L3												
2	Design and Evaluate heat sinks with optimal material choice, geometry, and surface treatments, including advanced configurations like pin-fin and vapor chamber heat sinks	L3												
3	Evaluate and Optimize different cooling methods, including heat sinks, liquid cooling, and advanced technologies like thermoelectric coolers and heat pipes, to enhance thermal performance	L4												
4	Analyze micro/mini channel cooling technologies to manage heat dissipation in high-density and high-power electronic applications	L3												
5	Simulate and Predict the thermal behavior of electronic systems using Matlab and CFD tools to develop and refine cooling strategies	L4												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	-	3	1	1	1	2	2	1	1	3	2
CO2	3	2	3	-	3	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	3	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	3	1	1	1	2	2	1	1	3	2
CO5	3	2	3	-	3	1	1	1	2	2	1	1	3	3
CO6	3	3	2	-	3	1	1	1	2	2	1	1	3	2
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

TEXT BOOKS:

- Frank P. Incropera and David P. DeWitt (2006) "Fundamentals of Heat and Mass Transfer", 6th Edition, John Wiley & Sons, Inc.
- D. Steinberg (1991). Thermal Management of Electronic Systems" John Wiley & Sons.

REFERENCE BOOKS:

- Andreas C. Papadakis (2015) "Thermal Design and Thermal Behaviour of Radio Frequency Devices" - CRC Press.

E-Resources:

- <https://nptel.ac.in/courses/113107078>
- <https://nptel.ac.in/courses/103105219>
- <https://nptel.ac.in/courses/112107221>
- <https://www.coursera.org/learn/crystal-structures-and-properties-of-metals?>

Skill Enhancement Course-III

Skill Enhancement Course-III CAE LAB-I (CATIA) [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 13+26 Hours
L–T–P–S	: 1–0–2–0		
Course Learning Objectives: This Course will enable students to: 1. Develop proficiency in using CATIA software for creating and editing 2D sketches and 3D models. 2. Equip students with the skills to design and modify complex parts and assemblies using CATIA's part and assembly workbenches. 3. Enhance students' ability to create and manage detailed surface models and perform advanced surface operations. 4. Prepare students to generate professional engineering drawings and documentation, including standard views, dimensions, and annotations, using CATIA's drafting tools.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

UNIT – I : Introduction to CATIA	09 Hours
• Overview of CATIA interface and functionalities. • Basics of 2D sketching: creating and editing sketches. • Constraints and dimensions in sketches. • Simple sketch-based features: extrude, revolve, and sweep.	
UNIT – II: Part Design Fundamentals	09 Hours
• Introduction to part design workbench.	

- Creating and modifying basic solid features: pads, pockets, shafts, and grooves. - Boolean operations: add, subtract, and intersect. - Creating complex geometries using multi-section solid features.	
UNIT – III: Assembly Design	06 Hours
- Introduction to assembly workbench and its interface. - Creating and managing assembly components. - Applying constraints to assemble parts accurately. - Techniques for managing large assemblies.	
UNIT – IV: Surface Design	07 Hours
- Introduction to generative shape design workbench. - Creating and editing basic surfaces: extrude, revolve, sweep, and loft. - Surface operations: trim, split, join, and fillet. - Advanced surface modeling techniques.	
UNIT – V: Drafting and Documentation	08 Hours
- Introduction to drafting workbench and its tools. - Creating standard views from 3D models. - Adding dimensions, annotations, and symbols to drawings. - Generating bill of materials (BOM) and creating detailed engineering drawings.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Create and manipulate complex 2D sketches and 3D models using CATIA's sketching and part design tools to meet specific design requirements.	L2 & L3
2	Construct and optimize intricate assemblies by applying appropriate constraints and managing large assemblies efficiently within CATIA.	L2 & L3
3	Design and refine advanced surface models, employing a variety of surface operations to achieve precise and complex geometries.	L3
4	Generate and evaluate comprehensive engineering drawings and documentation, ensuring accuracy and adherence to industry standards using CATIA's drafting tools.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2		2				1					
CO2	3	2	2		2				1					
CO3	3	2	2						1					
CO4	3	2	2		2				1					

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. Tickoo Sham, (2016)"CATIA V5-6R2015 Basics: Sketcher, Part, and Assembly Design"
CADCIM Technologies,.

Reference Books:

1. Richard Cozzens (2013) "CATIA V5 Workbook Release V5-6R2013", SDC Publications.

Skill Enhancement Course-III CAE LAB-II (ANSA) [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 13+26 Hours
L–T–P–S	: 1–0–2–0		
Course Learning Objectives: This Course will enable students to: 2. Enable students to learn and apply ANSA – a finite element pre-processor for industry problems 3. Enable students to learn the process for complex FEM (Finite Element Modelling) for structural and CFD analyses using 2D & 3D elements for selected industry problems, including how to model mechanical joints (welds, bolts, rivets etc.), mid-surface extraction, joining of different sub-systems, basic quality checks etc. 4. Full model checks as per the industry standards			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

UNIT – I	09 Hours
• Introduction to FEA Overview of FEA with some basic examples and explaining the importance of mathematical model generation to carry out different analyses • Reading and translation of CAD files and introduction to TOPO menu Main terms of TOPO Menu, changing FEM disciplines between different menus, Geometry clean up, preparing model for surface meshing, switch to Mesh menu and explain about some basic options in Mesh menu ex: perimeters, macros, mesh generator etc. • Meshing for Sheetmetal and plastic parts	

Middle Surface Extraction approach like Skin and Casting, Mesh generation and Quality corrections	
UNIT – II	
09 Hours	
Introduction to Part Manager, Property and Material assignment Creating parts, groups and meta data carried from CAD software, assigning property and materials for entities • Handling of Sheetmetal features Identification of features like holes, stamps, beads etc, and definition of design actions, mesh treatment. Collaboration of feature manager with morphing module. • Connections of Parts Overview of connection manager, different types of weld representation (seam weld, spot weld), and bolt definition (both 1D and 3D) • Boundary condition for static load case Preparing model to carry out linear load case like SPC, load definition (point load and distributed load), header creation and output the file in industry standard solver format	
UNIT – III	
06 Hours	
Tetrahedral and Hexahedral mesh generation Typical solid parts demonstration to generate 2D tria mesh and convert them to tetra mesh. Overview of map, extrude, solid build options and mesh quality corrections.	
UNIT – IV	
07 Hours	
Hybrid mesh generation for CFD external aerodynamics Geometry healing, batch mesh scenarios, quality corrections, mesh refining process like size box and layer generation. Overview of interfaces using property cards. 3D model generation with solution details.	
UNIT – V	
08 Hours	
•Morphing module for design modifications DFM (Direct Fit Morphing) options like rotate, translate, glide, sweep etc for external aerodynamics 2D mesh model • Coupling of ANSA with optimizers Creation of parameters, DOE (Design of Experiments) for linear cases	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	•Apply FEA principles to read, translate, and prepare CAD models for meshing, including geometry cleanup and mesh generation for sheet metal and plastic parts.	L2 & L3
2	Design and manage parts using modeling tool, including property and material assignment, handling sheet metal features, and defining connections such as welds and bolts.	L2 & L3
3	Generate tetrahedral and hexahedral meshes for solid parts, perform quality corrections, and apply hybrid mesh generation techniques for CFD external aerodynamics.	L3

4	Utilize the morphing module for design modifications and integrate CATIA with optimizers to perform design of experiments (DOE) for linear cases.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2		2				1					
CO2	3	2	2		2				1					
CO3	3	2	2						1					
CO4	3	2	2		2				1					
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

Reference Book:

1: ANSA version 22 Tutorial Guide - 2021

PROFESSIONAL ELECTIVE-1

Sensors & Actuators [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L–T–P–S	: 3–0–0–0		
Course Learning Objectives: This Course will enable students to: 1. Understand the fundamental principles and characteristics of various sensors and actuators used in mechanical systems. 2. Analyze the performance parameters and control mechanisms of sensors and actuators to optimize their applications in engineering solutions. 3. Explore advanced sensor technologies and their integration into mechanical systems for enhanced functionality and reliability. 4. Evaluate the theoretical aspects of sensor and actuator networks, including smart sensors and IoT applications in mechanical engineering. 5. Critically assess real-world case studies to understand the practical implications and ethical considerations of deploying sensors and actuators in industry.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. ● Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. ● Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. ● Show Video/animation films to explain functioning of various concepts. ● Encourage Collaborative (Group Learning) Learning in the class. ● To make Critical thinking, ask at least three Higher order Thinking questions in the class. ● Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. ● Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. ● Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			

UNIT – I : Principles of Sensors	09 Hours
Introduction to Sensors: Definitions, classifications, and roles in mechanical systems. Sensor Characteristics: Accuracy, sensitivity, range, resolution, and repeatability. Mechanical and Electromechanical Sensors: Emphasis on strain gauges, accelerometers, and pressure sensors. Theoretical Foundations: Understanding the physics and mechanics behind sensor operation.	
UNIT – II: Principles of Actuators	09 Hours
Introduction to Actuators: Overview of types and applications in mechanical engineering. Mechanical Actuators: Detailed theory on hydraulic, pneumatic, and electromechanical actuators. Performance Parameters: Force, speed, energy efficiency, and control characteristics. Theoretical Analysis: Studying the mechanical principles that govern actuator performance.	
UNIT – III: Sensor and Actuator Control Theory	06 Hours
Control Systems Overview: Basics of control theory relevant to sensors and actuators. Feedback and Feedforward Control: Understanding how these systems are applied in mechanical contexts. Dynamic Behavior of Actuators: Modeling and simulation of actuators under various control strategies. Theoretical Exercises: Analyzing control system designs through theoretical problems and simulations.	
UNIT – IV: Advanced Sensor Technologies	07 Hours
Smart Sensors and IoT: Concepts of smart sensors, integration with IoT, and implications for mechanical systems. Wireless Sensor Networks (WSN): Theoretical basis for design and implementation of WSNs. Sensor Fusion: Techniques for combining multiple sensor outputs to improve accuracy and reliability. Discussion on Emerging Technologies: Focus on MEMS, nanosensors, and their impact on mechanical engineering.	
UNIT – V: System Integration and Case Studies	08 Hours
Designing Integrated Systems: Theoretical approaches to integrating sensors and actuators into mechanical systems. Case Studies: Examination of real-world applications in automotive, aerospace, and industrial automation. Ethical and Environmental Considerations: Discussing the implications of sensor and actuator technology in mechanical engineering. Review and Future Trends: Exploring current research and future directions in sensor and actuator technology.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply knowledge of sensor and actuator characteristics to select appropriate technologies for specific mechanical engineering applications.	L2 & L3
2	Design and analyze control systems for actuators using advanced control theories to ensure optimal performance in mechanical setups.	L2 & L3
3	Integrate and configure smart sensors and wireless networks in mechanical systems, demonstrating an understanding of complex system requirements and functionalities.	L3

4	Synthesize information from diverse sensor inputs through sensor fusion techniques to improve system accuracy and reliability in engineering projects.	L4
5	Critique and propose improvements to existing sensor and actuator systems in mechanical engineering case studies, focusing on sustainability and ethical considerations.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	1	1	1	2	2	1	1	3	2
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	2	3	-	-	2	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	2
CO5	3	2	3	-	-	2	1	2	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. Clarence W. de Silva (2015). "Sensors and Actuators: Engineering System Instrumentation", CRC Press, 2nd Edition.
2. W. Bolton, (2015) "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", Pearson, 6th Edition.

References:

1. David G. Alciatore and Michael B. Hstand (2018) "Introduction to Mechatronics and Measurement Systems", McGraw-Hill Education, 5th Edition.
2. Placko, D. (Ed.). (2013). Fundamentals of instrumentation and measurement. John Wiley & Sons.

AUTOMATED MANUFACTURING SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L–T–P–S	:	3–0–0–0			
Course Learning Objectives: This Course will enable students to: 1. Introduce students to the fundamental concepts and components of automated manufacturing systems. 2. Provide knowledge on the configuration, programming, and control of industrial robots. 3. Explain the principles and implementation of computer-integrated manufacturing systems. 4. Teach the design and application of various automated material handling systems. 5. Equip students with the skills to apply quality control and monitoring techniques in automated manufacturing environments.					
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.					
UNIT – I : Introduction to Automated manufacturing Systems					09 Hours
Overview of manufacturing systems. Evolution and types of automation. Key components of automated systems. Role of automation in manufacturing. Economic and strategic importance					
UNIT – II: Industrial Robotics and Automation					09 Hours
Basics of industrial robotics. Robot configurations and applications. Robotic work cells and their integration. Programming and controlling robots. Safety and maintenance of robotic systems					

UNIT – III: Computer-Integrated Manufacturing (CIM)	06 Hours
Concepts of CIM. Components of CIM: CAD, CAM, and CAPP. CIM architecture and data flow Integration of CIM with ERP and MES. Benefits, challenges, and case studies	
UNIT – IV: Automated Material Handling Systems	07 Hours
Types of material handling systems. Automated storage and retrieval systems (AS/RS). Conveyors, AGVs, and industrial trucks. Design principles and implementation. Case studies and applications	
UNIT – V: Quality Control and Monitoring in Automated Systems	08 Hours
Principles of quality control in manufacturing. Automated inspection and testing techniques. Role of sensors and data acquisition systems. Statistical process control (SPC) and its applications. Quality management systems (QMS)	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Design and integrate key components of automated manufacturing systems.	L2 & L3
2	Program and control industrial robots for various applications.	L2 & L3
3	Implement computer-integrated manufacturing systems, including CAD, CAM, and CAPP.	L3
4	Develop automated material handling systems using AS/RS, conveyors, and AGVs.	L4
5	Apply quality control techniques and statistical process control in automated systems.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	2	-	-	1	1	1	2	2	1	1	3	2
CO3	3	2	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	2	-	-	1	1	1	2	2	1	1	2	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks

1. Mikell P. Groover (2014) "Automation, Production Systems, and Computer-Integrated Manufacturing" 4th edition Pearson.
2. John J. Craig (2017) "Introduction to Robotics: Mechanics and Control" Pearson Education.

Reference Books

1. Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2009). Robotics: Modelling, Planning and Control. Springer.
2. Groover, M. P. (2020). Fundamentals of Modern Manufacturing: Materials, Processes, and Systems (6th ed.). Wiley.

INTRODUCTION TO HYBRID & ELECTRIC VEHICLES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This course will enable students to:

1. Explain the basics of electric and hybrid electric vehicles, their architecture
2. Discuss the design and component sizing and the power electronics devices used in electric and hybrid electric vehicles.
3. Analyse various electric drives suitable for electric and hybrid electric vehicles.
4. To help the students for understanding the concept of powertrain sizing and energy management system
5. Understanding of different energy storage technologies and power electronics system used for electric and hybrid electric vehicles

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I	09 Hours
HYBRID VEHICLE ARCHITECTURE: Introduction - Concept of Hybrid Electric Drivetrains - Architectures of Hybrid Electric Drivetrains - Series and Parallel Hybrid Electric Drivetrains – Coupling Modes - Operating Modes – Hybridization factor – PHEV – Performance characteristics Electric Vehicle Architecture: Introduction- Configurations - Traction Motor Characteristics - Tractive Effort and Transmission Requirement – Power Flow Control in Electric Drivetrain – Positioning of Motors – Vehicle Performance - Tractive Effort in Normal Driving - Energy Consumption – Single and Multi Motor drives.	
UNIT - II	9 Hours
POWERTRAIN COMPONENTS OF HYBRID AND ELECTRIC VEHICLES: Traction Motor Types – Configuration and Control - DC Motor- Brushless DC Motor – BLDC Motor Control - Switched Reluctance Motor – AC Induction – Motor Drives and Introduction to Power electronic components – Electronic Control Unit of Motors – Various Control Modes – Drive system Efficiency SIZING OF POWERTRAIN SYSTEMS: Fundamentals of Vehicle Propulsion – Vehicle Resistance – Basics - sizing and rating of powertrain components - Introduction to tractive force- torque and power - Basics and factors influenced on tractive force- torque and power (2w, 3w &4w) - Calculation of battery pack- motor torque and power requirements for EV-Case study – Operating fuel economy	
UNIT - III	06 Hours
POWERTRAIN ENERGY MANAGEMENT SYSTEM Introduction to energy management strategies - classification of energy management strategies -rule based and optimization strategies - real-time working of energy management system in HEV -model-based design and simulation process - Implementation issues of energy management strategies	
UNIT - IV	08 Hours
TRANSMISSION SYSTEM FOR HYBRID AND ELECTRIC POWERTRAIN: Need for transmission system in EV and HEV – Torque and Speed Matching - Design consideration of transmission system - Types and Procedure, Power Transmission – Power flow and management, Powertrain components for series -parallel - series-parallel hybrid- Power and Torque distribution- Types of transmission - Single Speed – Multi-speed transmission in EV-Planetary Gear box in HEV- Drive shaft in EV and HEV	
UNIT - V	07 Hours
ENERGY STORAGE SYSTEM AND POWER ELECTRONICS IN EV AND HEV Batteries – Ultracapacitor -Supercapacitor - Fuel Cells, and Controls - Flywheel Energy Storage - Hydraulic Energy Storage - Hybrid Fuel Cell Energy Storage. Power electronics including switching - AC-DC, DC-AC conversion - electronic devices and circuits used for control and distribution of electric power- Thermal Management of HEV Power Electronics	

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Analyze the architecture and performance characteristics of hybrid and electric vehicle drivetrains.	L4												
2	Evaluate the efficiency and control modes of different traction motors used in hybrid and electric vehicles.	L3												
3	Design and size powertrain components for hybrid and electric vehicles based on vehicle propulsion fundamentals and tractive force requirements.	L3												
4	Implement and optimize energy management strategies for hybrid and electric vehicle powertrains in real-time applications.	L4												
5	Assess the design considerations, power flow, and transmission systems used in hybrid and electric vehicles, including single and multi-speed transmissions and energy storage systems.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C03	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	2
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C06	3	3	2	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

TEXT BOOKS:

1. Callister, W. D., Jr. (2020). Materials Science and Engineering: An Introduction (2nd ed.). John Wiley & Sons, Inc.
2. Raghavan, V. (2019). Materials Science and Engineering. Prentice-Hall of India Pvt. Ltd.

REFERENCE BOOKS:

1. Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. M. (2018). Modern electric, hybrid electric, and fuel cell vehicles. CRC press
2. Denton, T. (2020). Electric and hybrid vehicles. Routledge

SOLAR ENERGY ENGINEERING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – V	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Estimate solar radiation using models and empirical methods 2. Explain the operation principles of various solar thermal collectors 3. Perform performance analysis of PV systems under different environmental conditions 4. Integrate energy storage solutions into solar energy systems, select appropriate storage technologies based on application requirements 5. Assess diverse applications of solar energy in heating, cooling, and power generation	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours
FUNDAMENTALS OF SOLAR ENERGY: Solar radiation basics: nature, composition, and solar constant, Geometric relations: incidence, azimuth, zenith angles, Solar radiation measurement techniques: pyranometers, pyrliometers, Models and methods for estimating solar radiation	
UNIT – II	08 Hours
SOLAR THERMAL ENERGY SYSTEMS: Types of solar collectors: flat-plate, evacuated tube, concentrating, Thermal performance metrics and efficiency parameters, Heat transfer mechanisms: conduction, convection, radiation, Design and optimization of solar thermal systems	

UNIT - III		06 Hours
SOLAR PHOTOVOLTAIC SYSTEMS: Photovoltaic (PV) principles: photoelectric effect, solar cell operation, Types of PV technologies: crystalline silicon, thin-film, emerging technologies, Components of PV systems: panels, inverters, batteries, Design and performance analysis of PV systems		
UNIT - IV		08 Hours
SOLAR ENERGY STORAGE AND CONVERSION: Thermal energy storage methods: sensible and latent heat storage, Electrical energy storage: battery technologies, Conversion technologies: converting stored solar energy, Integration strategies for enhanced system performance		
UNIT - V		09 Hours
APPLICATIONS AND ECONOMICS OF SOLAR ENERGY: Solar heating and cooling applications, Solar power generation: residential, commercial, utility-scale. Economic analysis: cost-benefit, payback period, LCOE Policy impact: government incentives, regulations		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Evaluate solar radiation data using empirical models and measurement techniques to optimize the orientation and tilt angles for maximum energy capture	L4
2	Develop detailed designs of solar thermal systems, considering factors such as collector type, thermal storage, and heat transfer mechanisms. Evaluate their performance and efficiency metrics under varying environmental conditions	L3
3	Implement advanced PV system designs incorporating different PV technologies (e.g., crystalline silicon, thin-film) and components (panels, inverters, batteries). Analyze and optimize their performance characteristics for residential, commercial, and utility-scale applications	L3
4	Apply knowledge of thermal and electrical energy storage technologies to integrate efficient energy storage solutions into solar energy systems. Analyze the effectiveness of conversion technologies in maximizing energy utilization	L4
5	Develop comprehensive strategies for the deployment of solar energy solutions in residential, commercial, and industrial sectors, considering economic viability, policy implications, and environmental sustainability	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	2	3	-	-	1	1	1	2	2	1	1	3	2
C05	3	3	3	-	-	2	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. S. P. Sukhatme, J K. Nayak (2017), Solar Energy, 4th Edition – McGraw Hill Education

REFERENCE BOOKS:

1. John A.Duffie, William A.Beckman (2013), Solar Engineering of Thermal Processes, John Wiley & Sons.
2. Garg H P, Prakash J (2013), Solar Energy – Fundamentals and Applications, Tata McGraw Hill

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ph14/preview
2. <https://archive.nptel.ac.in/courses/112/105/112105051/>

REFRIGERATION AND AIR CONDITIONING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This Course will enable students to:

1. Study the methods of refrigeration, Carnot cycle, Unit of refrigeration and coefficient of performance
2. Discuss classification and properties of refrigerants
3. Describe the Vapour compression and Vapour absorption systems
4. Understand psychrometric properties and processes
5. Study Air conditioning systems and air conditioning loads
6. Understand the measuring instruments and sensors used in air conditioning

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I	08 Hours
Methods of refrigeration, ice refrigeration, evaporative refrigeration, air refrigeration, vapour refrigeration, dry ice refrigeration, pulse tube refrigeration, thermo-acoustic refrigeration, reverse Carnot cycle, block diagram of refrigerator & modified reverse Carnot cycle (Bell Coleman cycle). Unit of refrigeration and coefficient of performance.	
UNIT – II	06 Hours
Refrigerants: Classification of refrigerants, desirable properties of refrigerants, environmental issues, Ozone depletion potential and global warming potential & life cycle climate	

performance. Selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes.	
UNIT – III	08 Hours
Vapour Compression Systems: Vapor compression cycle: p-h and T-s diagrams – deviations from theoretical cycle – sub cooling and super heating-effects of condenser and evaporator pressure on COP- multi pressure system – low temperature refrigeration – cascade systems – problems. Vapour Absorption Systems: Introduction, working of simple vapour absorption system, desirable properties of binary mixture (aqua-ammonia), Lithium-Bromide (Li- Br) absorption system, performance evaluation, applications and comparison between vapour compression system and vapour absorption system.	
UNIT – IV	08 Hours
Properties of moist air-Gibbs Dalton law, specific humidity, dew point temperature, degree of saturation, relative humidity, enthalpy, humid specific heat, wet bulb temperature thermodynamic wet bulb temperature, psychrometric chart; psychrometric processes.	
UNIT – V	09 Hours
Air conditioning: Introduction, Classification, ASHRAE Nomenclature, Applications, Different Air-Conditioning Systems: Central, Unitary, Window, Packaged & Transport Air conditioning loads: Outside and inside design conditions; Sources of heat loads and calculations; Air filters; air conditioning systems with controls: temperature, pressure and humidity sensors, actuators & safety controls.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze different refrigeration methods and evaluate their performance characteristics and applications.	L4
2	Classify refrigerants based on properties, environmental impact, and select suitable refrigerants for specific applications.	L3
3	Assess the performance of vapor compression and vapor absorption systems, including cycle deviations and efficiency improvements.	L3
4	Calculate properties of moist air using psychrometric principles and perform relevant psychrometric process calculations.	L4
5	Design various air conditioning systems by performing load calculations and integrating appropriate control mechanisms.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C03	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	2
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. Arora, C. P. (2008). Refrigeration and Air Conditioning. Tata McGraw-Hill.
2. Prasad, M. (1983). Refrigeration and Air Conditioning. Wiley Eastern Ltd.

REFERENCES BOOKS :

1. Dossat, R. J. (2000). *Principles of refrigeration* (S.I. version). Wiley Eastern Ltd.

MANAGEMENT AND ENTREPRENEURSHIP

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This course will enable students to:

1. Utilize management functions and planning steps to develop plans that achieve organizational goals. Students will practice applying these functions and steps in case studies and simulations to create effective organizational plans.
2. Describe how various organizational structures and staffing processes enhance operational efficiency. Students will explore different structures and staffing models, understanding their impact on efficiency through real-world examples.
3. Recall the principles of social responsibility and ethical practices in business. Students will list and memorize key principles, preparing them to recognize and discuss these concepts in business scenarios.
4. Explain how various strategies can enhance the performance and sustainability of small-scale industries. Through lectures and discussions, students will learn to articulate strategies that improve small-scale industry performance and sustainability.
5. Utilize project management tools and techniques to plan, execute, and evaluate successful projects. Students will engage in hands-on projects, using management tools to experience the full lifecycle of project management from planning to evaluation.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT – I Management and Planning	09 Hours
Management: Definition, Importance – Nature and Characteristics of Management, Management Functions, Roles of Manager, Levels of Management, Managerial Skills, Management & Administration, Management as a Science, Art & Profession. (Text Book-1: Chapter 1: 11 to 39). Planning: Nature, Importance and Purpose of Planning, Types of Plans, Steps in Planning, Limitations of Planning, Decision Making – Meaning, Types of Decisions- Steps in Decision Making. (Text Book-1: Chapter 2:69-125).	
UNIT – II: Organizing and Staffing	09 Hours
Organizing and Staffing: Meaning, Nature and Characteristics of Organization – Process of Organization, Principles of Organization, Departmentalization, Committees – meaning, Types of Committees, Centralization Versus Decentralization of Authority and Responsibility, Span of Control (Definition only), Nature and Importance of Staffing, Process of Selection and Recruitment. (Text Book-1: Chapter 4: -195-235).	
UNIT – III: Social Responsibilities of Business:	06 Hours
Social Responsibilities of Business: Meaning of Social Responsibility, Social Responsibilities of Business towards Different Groups, Social Audit, Business Ethics and Corporate Governance. Entrepreneurship: Definition of Entrepreneur, Importance of Entrepreneurship, concepts of Entrepreneurship, Characteristics of successful Entrepreneur, Classification of Entrepreneurs, Intrapreneur – An Emerging Class, Comparison between Entrepreneur and Intrapreneur, Myths of Entrepreneurship, Entrepreneurial Development models, Entrepreneurial development cycle, Problems faced by Entrepreneurs and capacity building (Text Book-1: Chapter 4:-(235- 301).	
UNIT – IV: Modern Small Business Enterprises:	07 Hours
Modern Small Business Enterprises: Role of Small-Scale Industries, Concepts and definitions of SSI Enterprises, Government policy and development of the Small-Scale sector in India, Growth and Performance of Small-Scale Industries in India, Sickness in SSI sector, Problems for Small Scale Industries, Impact of Globalization on SSI, Impact of WTO/GATT on SSIs, Ancillary Industry and Tiny Industry (Definition only). Institutional Support for Business Enterprises: Introduction, Policies & Schemes of Central-Level Institutions, State-Level Institutions. (Text Book-2)	
UNIT – V: Project Management:	08 Hours
Project Management: Meaning of Project, Project Objectives & Characteristics, Project Identification- Meaning & Importance; Project Life Cycle, Project Scheduling, Capital Budgeting, Generating an Investment Project Proposal, Project Report-Need and Significance of Report, Contents, Formulation, Project Analysis-Market, Technical, Financial, Economic, Ecological, Project Evaluation and Selection, Project Financing, Project Implementation Phase, Human & Administrative aspects of Project Management, Prerequisites for Successful Project Implementation. (Text Book-2)	
New Control Techniques- PERT and CPM, Steps involved in developing the network, Uses and Limitations of PERT and CPM. (Text Book-2)	

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Apply management principles to organize and lead teams effectively, making informed decisions and planning strategically to meet organizational goals.	L3												
2	Implement robust staffing and recruitment processes to build efficient organizational structures and enhance workforce capabilities.	L3												
3	Demonstrate a commitment to social responsibility and ethical practices in business, conducting social audits and promoting sustainable practices.	L4												
4	Analyze the impacts of globalization on small-scale industries and utilize institutional support to foster growth and mitigate challenges in the SSI sector.	L3												
5	Manage complex projects from inception to completion, using advanced techniques like PERT and CPM to optimize resources and achieve project objectives efficiently.	L4												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	2	1	2	3	2	2	1	3	2
CO2	2	3	2	-	-	1	1	1	3	2	2	1	3	2
CO3	2	2	2	-	-	3	3	3	2	2	1	1	3	3
CO4	3	3	2	-	-	2	1	1	2	2	2	1	3	3
CO5	3	3	3	-	-	1	1	1	3	2	2	1	3	2
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

Textbooks:

1. Koontz, H., & Weihrich, H. (2020). Management: Principles and Applications (14th ed.). McGraw-Hill Education.
2. Gray, C. F., & Larson, E. W. (2018). Project Management: The Managerial Process (7th ed.). McGraw-Hill Education.

Reference Books:

1. Kotler, P., & Lee, N. (2005). Corporate Social Responsibility: Doing the Most Good for Your Company and Your Cause (1st ed.). Wiley.
2. Longenecker, J. G., Petty, J. W., Palich, L. E., & Hoy, F. (2019). Small Business Management: Launching & Growing Entrepreneurial Ventures (18th ed.). Cengage Learning.

FINITE ELEMENT ANALYSIS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	:		Credits	:	04
Hours / Week	:	05 Hours	Total Hours	:	39+26 Hours
L-T-P-S	:	3-0-2-0			

Course Learning Objectives:

This course will enable students to:

1. Understand the fundamental principles and applications of computational methods like finite difference and finite volume methods in engineering analysis.
2. Develop proficiency in creating and manipulating element matrices for analyzing various physical phenomena including torsion, fluid flow, and heat transfer.
3. Gain practical skills in applying principles of virtual work, variational methods, and Galerkin's method to solve real-world engineering problems.
4. Master the use of finite element analysis for structural evaluation, including trusses, beams, and axi-symmetric stress analysis.
5. Learn to effectively utilize commercial finite element method (FEM) software for dynamic analysis, numerical integration, and error analysis.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I		09 Hours
Introduction to computational methods, Finite difference method, Finite volume methods, Direct stiffness method, Integral formulation for numerical Solution – Variational method, Method of weighted residuals, Potential energy formulations; Principle of virtual work, Division of the region into elements - One dimensional linear element, Linear triangular element, Bilinear rectangular element, Representation for scalar and vector fields, Global, local and natural coordinate systems in one, two and three dimensions.		
UNIT - II		09 Hours
Governing differential equations; Integral equations for the element matrices, Triangular element matrix, Torsion of noncircular sections, General theory – Twisting of a square bar, Shear stress components, Evaluation of the twisting torque, Flow of an Ideal Fluid – Potential Formulation, Groundwater Flow, Flow Around a Cylinder, Other field problems, Derivative boundary conditions – 1D, Derivative boundary conditions – 2D,		
UNIT - III		06 Hours
Heat transfer by conduction, The one dimensional fin – 1, The one dimensional fin –2, The composite walls, The two-dimensional fin, Boundary conditions, Long two-dimensional bodies – 1, Long two-dimensional bodies – 2, Axi-symmetric field problems, The differential equation – Axi-symmetric elements, Galerkin's method, Element matrices,		
UNIT - IV		07 Hours
The axial force member - Element matrices, The truss element – Element matrices, Analysis of a pinned truss – 1, Analysis of a pinned truss – 2, A Beam element, Shape functions, Element matrices, Analysis of a statically indeterminate beam – 1, Analysis of a statically indeterminate beam – 2, A plane frame element – Element matrices, Two dimensional stress analysis - Stress, strain and Hooke's Law, The strain displacement equations, Two dimensional elasticity - Plane stress and plane strain, The displacement equations, The element matrices, Element stresses, Axi-symmetric stress analysis - Element matrices, Surface loads,		
UNIT - V		08 Hours
Iso-parametric elements in one and two dimensions, use of higher order elements, Element matrices, Introduction to Transient domain & Dynamic analysis, Changing the variables of integration- One-dimensional integrals, Two- dimensional integrals, Numerical Integration techniques- one-dimensional integrals, Quadrilateral regions, Triangular regions; Evaluating [B]; Evaluating the surface integrals, Pre and post processing, capability of commercially available FEM packages, Error analysis		
List of Laboratory/Practical Experiments activities to be conducted (if any) :28		
1.	Bars of constant cross section area, tapered cross section area and stepped bar	
2.	Trusses (Minimum 2 exercises) Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc; (Minimum 6 exercises)	
3.	Dynamic analysis - Fixed – fixed beam for natural frequency determination - Bar subjected to forcing function - Fixed – fixed beam subjected to forcing function	
	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises)	

4.	Stress analysis of a rectangular plate with a circular hole

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply finite element methods such as finite difference and finite volume methods to solve complex engineering problems involving scalar and vector fields.	L3
2	Develop and analyze element matrices and use computational techniques to evaluate torsion in non-circular sections and fluid flow scenarios.	L3
3	Utilize advanced numerical methods to analyze heat transfer through various geometrical configurations, including fins and composite walls.	L4
4	Implement structural analysis on trusses, beams, and frames using element matrices and evaluate the resulting stress and strain using Hooke's Law.	L3
5	Perform dynamic and transient analysis using isoparametric elements and numerical integration techniques, ensuring accurate pre and post-processing in commercial FEM software.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C05	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C06	3	3	3	-	3	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Segerlind, L. J (2006). Applied Finite Element Analysis. John Wiley and Sons.
2. Ramamurthy, G. (2009). Applied Finite Element Analysis. I.K. International Publishing House.

Reference Books:

1. Cook, R. D., Malkus, D. S., Plesha, M. E., & Witt, R. J. (2007). Concepts and Applications of Finite Element Analysis (4th ed., 1st reprint). Wiley Student Edition.
2. Rao, S. S. (2007). The Finite Element Method in Engineering. Butterworth-Heinemann (An imprint of Elsevier), Published by Elsevier India Pvt. Ltd.

MECHANICAL VIBRATIONS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	:		Credits	:	03
Hours / Week	:	04 Hours	Total Hours	:	26+26 Hours
L-T-P-S	:	2-0-2-0			

Course Learning Objectives:

This course will enable students to:

1. Understand the fundamental principles of vibration in mechanical systems, including natural frequencies, damping, and the effects of vibration.
2. Master the analysis of forced and free vibrations in single and multiple degree of freedom systems with and without damping.
3. Develop skills in designing and optimizing vibration absorbers and isolators for mechanical systems to reduce the impact of vibrations.
4. Gain proficiency in applying numerical methods for the analysis of torsional vibrations and critical speeds in complex mechanical assemblies.
5. Learn to use modern vibration measurement tools and AI-based techniques for condition monitoring and fault diagnosis in engineering applications.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method but different *types of teaching methods* that may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
- Show **Video/animation** films to explain the functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
- Adopt **Problem-Based Learning**, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.
- **Practical experimentation** of material testing of different metals and alloys

UNIT - I		05 Hours
Introduction, classification of vibration systems, harmonic motion, natural frequency & response, effects of vibration, superposition of simple harmonic motions, Single degree freedom system-equation of motion, Free vibration, equivalent systems, torsional vibrations, vibrations of systems with viscous damping, Logarithmic decrement, energy dissipation in viscous damping.		
UNIT - II		06 Hours
Forced vibration, harmonic excitation with viscous damping, steady state vibrations, forced vibrations with rotating and reciprocating unbalance, support excitation, vibration isolation, transmissibility, displacement, velocity and acceleration measuring instruments.		
UNIT - III		05 Hours
Introduction, principal modes, torsional system with damping, coupled system, principle of vibration absorber, undamped dynamic vibration absorbers, torsional vibration absorber, centrifugal pendulum absorbers, vibration isolators and dampers.		
UNIT - IV		05 Hours
Numerical Analysis- Influence coefficients, reciprocal theorem, torsional vibration of multi-degree rotor system, Rayleigh's method, Dunkerely's, Holzer's and Stodola methods, Rayleigh-Ritz method, critical speed of shafts, whirling of uniform shaft, shaft with one disc with and without damping, multi-disc shafts, secondary critical speed.		
UNIT - V		05 Hours
Vibration instruments – transducer, vibrometer, accelerometer, seismometer, vibration pickup, proximity probe spectrum analyzer, principle of seismic instruments, frequency measuring instruments, diagnostic tools, Introduction to condition monitoring and fault diagnosis using Artificial Intelligence approach.		
List of Laboratory/Practical Experiments activities to be conducted (if any) :26		
1.	Plotting and analysis of various graphs of free and forced vibrations using	
2.	MATLAB.	
3.	Virtual lab exercises provided by MHRD	
4	Free and forced vibration	
5.	Whirling of the shaft and finding the critical speed of the shaft.	
6.	Students will be trained in MATLAB and ANSYS for solving simple vibration problems and using AI & ML techniques in condition monitoring.	

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Analyze and model single and multi-degree freedom systems to understand their natural frequencies, responses, and damping characteristics.	L3												
2	Design and evaluate vibration isolation systems and absorbers to mitigate unwanted vibrations in mechanical systems.	L3												
3	Apply numerical methods such as Rayleigh's, Dunkerley's, Holzer's, and Stodola's methods to analyze torsional and critical speed vibrations in complex rotor systems.	L4												
4	Utilize advanced vibration measuring instruments like vibrometers, accelerometers, and spectrum analyzers to assess and interpret vibration data.	L3												
5	Implement AI-based condition monitoring and fault diagnosis techniques to predict and prevent failures in mechanical systems.	L4												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C05	3	3	3	-	3	1	1	1	2	2	1	1	3	3
C06	3	3	3	-	3	1	1	1	2	2	1	1	3	3

Textbooks:

1. Rao, S. S. (2018). Mechanical Vibrations (6th ed.). Pearson Education Inc.
2. Thomson, W. T. (2001). Theory of Vibration with Applications (5th ed.). Prentice Hall.

References:

1. Rao, J. S., & Gupta, K. (1999). Introductory Course on Theory and Practice of Mechanical Vibrations. New Age International.
2. Ramamurthi, V. (2000). Mechanical Vibration Practice with Basic Theory (1st ed.). Narosa Publishing House.

MINOR PROJECT [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VI			
Subject Code	:	Credits	: 02
Hours / Week	: 03 Hours	Total Hours	: Hours
L-T-P-S	: 0-0-0-4		
Course Learning Objectives: This Course will enable students to: 1. Develop the ability to identify and define a relevant engineering problem through a comprehensive literature review and analysis. 2. Apply theoretical knowledge and practical skills to design and implement a feasible solution to the identified problem. 3. Enhance teamwork, communication, and project management skills by collaborating effectively with peers and faculty advisors. 4. Demonstrate innovation and creativity in the development and presentation of the project, including the preparation of detailed documentation and reports.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
Minor Project Content			
Students focuses on developing the ability to identify and define relevant engineering problems through comprehensive literature reviews and analysis. Students will apply theoretical knowledge and practical skills to design and implement feasible solutions to the identified problems. Emphasis will be placed on enhancing teamwork, communication, and project management skills by encouraging effective collaboration with peers and faculty advisors. The course will also promote innovation and creativity in project development and presentation, requiring students to prepare detailed documentation and reports to demonstrate their findings and solutions.			

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Identify and define a relevant engineering problem through comprehensive literature reviews and critical analysis.	L3												
2	Design and implement a feasible solution to the identified engineering problem using theoretical knowledge and practical skills.	L3												
3	Collaborate effectively with peers and faculty advisors, demonstrating enhanced teamwork, communication, and project management skills.	L4												
4	Prepare and present detailed project documentation and reports, showcasing innovation and creativity in the development and execution of the project.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3										2		3
CO2	3	3	2									2		3
CO3	3	3										1		3
CO4	3	3	2									2		3
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

INTERNSHIP [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code	:	Credits	: 02
Hours / Week	:	Total Hours	:
L-T-P-S	:	-----	
Course Learning Objectives: This Course will enable students to: 1. Provide hands-on industry experience to apply mechanical engineering concepts in real-world scenarios. 2. Develop practical skills and technical expertise through active participation in engineering projects. 3. Enhance professional skills, including communication, teamwork, and project management. 4. Foster an understanding of workplace dynamics and professional ethics in an engineering environment.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
Internship Content The internship start with an introduction to the objectives, expectations, workplace safety, professional behavior, and ethics, along with an overview of the host organization and its projects. Students were to receive training on industry-specific tools, software, and equipment, gaining hands-on experience in mechanical design, analysis, and manufacturing processes. Active involvement in ongoing engineering projects was intended to allow students to apply theoretical knowledge to practical tasks and problem-solving. Throughout the internship, students were expected to enhance their communication, teamwork, and leadership skills through group projects, meetings, presentations, and reports. They would also gain exposure to project management practices such as planning, scheduling, and resource allocation. Continuous assessment through supervisor feedback and self-reflection was to ensure progress. The internship was to culminate with the preparation of a			

comprehensive report detailing experiences, skills acquired, and project contributions, and a final presentation summarizing the internship outcomes and key learnings.

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Apply mechanical engineering theories to solve practical problems in a professional setting.	L3												
2	Demonstrate technical proficiency with industry-specific tools, software, and equipment.	L3												
3	Develop effective communication and teamwork skills through collaborative projects and professional interactions.	L4												
4	Analyze and evaluate engineering projects, preparing detailed reports and presentations on work and findings.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3										2		3
CO2	3	3	2									2		3
CO3	3	3										1		3
CO4	3	3	2									2		3

OPEN ELECTIVES-1

FLUID AND THERMAL ENGINEERING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Acquire an understanding of the fundamental principles of fluid mechanics and heat transfer and their relevance in various engineering contexts. 2. Develop the ability to analyze fluid behavior under different static and dynamic conditions using basic fluid dynamics principles. 3. Learn the methods of heat transfer, including conduction, convection, and radiation, and their applications in real-world scenarios. 4. Gain skills in evaluating and designing simple heat exchanger systems and understanding the factors affecting their performance. 5. Understand the environmental impacts of fluid and thermal systems and explore strategies for enhancing energy efficiency and sustainability in their design and operation.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction to Fluid Mechanics	06 Hours
Fundamentals of Fluid Mechanics: Properties of fluids, concept of viscosity, Newtonian and non-Newtonian fluids. Fluid Statics: Pressure variation in a fluid at rest, hydrostatic force on submerged surfaces, buoyancy and flotation. Fluid Dynamics: Concepts of flow visualization, streamlines, pathlines, streaklines, continuity equation, and Bernoulli's equation.	

UNIT – II: Fluid Flow Systems		10 Hours
Laminar and Turbulent Flow: Characteristics of laminar vs. turbulent flow, Reynolds number. Internal Flow: Flow through pipes, Darcy-Weisbach equation, friction factor, minor losses. External Flow: Drag and lift forces, flow around submerged objects like spheres and cylinders.		
UNIT – III: Heat Transfer Fundamentals		10 Hours
Modes of Heat Transfer: Conduction, convection, and radiation; understanding and application of each mode in engineering. Conduction: Fourier's law, thermal conductivity, heat transfer in steady and unsteady states. Convection: Newton's law of cooling, natural vs. forced convection, heat transfer coefficients.		
UNIT – IV: Applied Heat Transfer		07 Hours
Radiation Heat Transfer: Basic principles, black and grey surfaces, view factors, radiation exchange between surfaces. Heat Exchangers: Types of heat exchangers, overall heat transfer coefficient, effectiveness-NTU method. Phase Change Heat Transfer: Boiling, condensation, heat transfer during phase changes.		
UNIT – V: Thermal System Analysis		08 Hours
Thermodynamics and Thermal Systems: Review of first and second laws of thermodynamics, applications in real-world thermal systems. Energy Efficiency: Analysis of energy consumption, strategies for improving energy efficiency in thermal systems. Environmental Impact of Thermal Systems: Understanding the environmental aspects and sustainability considerations in the design and operation of thermal systems.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the principles of fluid mechanics to analyze and predict the behavior of fluids in both static and dynamic conditions.	L3
2	Design and evaluate systems involving internal and external fluid flows, considering factors like friction, drag, and lift.	L3
3	Utilize knowledge of conduction, convection, and radiation to solve practical heat transfer problems across various engineering applications.	L4
4	Analyze and optimize heat exchangers using the effectiveness-NTU method and assess phase change phenomena in thermal systems.	L3
5	Implement energy-efficient and environmentally sustainable practices in the design and operation of fluid and thermal systems.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	2	2	2	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Çengel, Y. A., & Cimbala, J. M. (2006). Fluid Mechanics: Fundamental and Applications. Tata McGraw-Hill Publishing Co. Ltd.
2. Çengel, Y. A., & Ghajar, A. J. (2014). Heat and Mass Transfer: Fundamentals and Applications (5th ed.). McGraw-Hill Education.

Reference Books:

1. Moran, M., Shapiro, H., Munson, B., & DeWitt, D. (2003). Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer. Wiley.
2. White, F. M. (2016). Fluid Mechanics (8th ed.). McGraw-Hill Education.

E-Resources:

20. <https://open.umn.edu/opentextbooks/textbooks/85>
21. <https://library.iitd.ac.in/index.php/node/81851>
22. [IC engine Major Parts and Its Function, Materials, Images, Manufacturing Method. \(learnmech.com\)](#)
23. [NPTEL :: Mechanical Engineering - NOC:IC Engines and Gas Turbines](#)

MATERIALS FOR ENGINEERING APPLICATIONS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This Course will enable students to:

1. Understand the basic classification and properties of engineering materials including metals, ceramics, polymers, and composites.
2. Gain proficiency in testing and characterizing material properties such as tensile strength, thermal conductivity, and electrical resistivity.
3. Acquire knowledge of materials suitable for high-temperature applications and their roles in industries like aerospace and power generation.
4. Learn the criteria for selecting materials for electronics and computing, including conductors, insulators, and semiconductor materials.
5. Explore the composition, advantages, and manufacturing processes of composite materials and their applications across various sectors.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I : INTRODUCTION TO ENGINEERING MATERIALS	06 Hours
An overview of the significance of materials in engineering, Classification of engineering materials based on their properties, such as metals, polymers, ceramics, and composites. Material properties and their importance in engineering design and applications.	
UNIT – II: MATERIAL PROPERTIES AND TESTING	10 Hours
Mechanical properties, including tensile strength, hardness, elasticity. Thermal properties, such as thermal conductivity and coefficient of thermal expansion. Electrical properties, including electrical conductivity and resistivity.	
UNIT – III: MATERIALS FOR HIGH-TEMPERATURE APPLICATIONS	10 Hours

High-temperature materials are essential in various engineering fields. This module focuses on: Materials that exhibit resistance to high temperatures, including refractory materials and super alloys. Applications of high-temperature materials in industries such as aerospace, power generation, and metallurgy. Thermal management materials used to dissipate heat effectively in electronic devices and other applications.

UNIT - IV: MATERIALS FOR ELECTRONICS AND COMPUTING

07 Hours

Conducting materials, such as metals and semiconductors, used in electronic circuits. Insulating materials to isolate and protect electronic components. Materials for electronic components, including resistors, capacitors, and semiconductors. Real-world case studies highlighting materials used in microprocessors and memory devices.

UNIT - V: COMPOSITE MATERIALS

08 Hours

The concept of composite materials and their composition. Advantages and disadvantages of composites. Applications of composites in various industries, including aerospace, automotive, and sports equipment. An overview of manufacturing processes for composites, including layup techniques and curing methods.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Evaluate and select appropriate engineering materials based on their mechanical, thermal, and electrical properties for specific engineering applications.	L3
2	Assess the suitability of materials for high-temperature environments, utilizing knowledge of refractory materials and superalloys in critical industry applications.	L3
3	Analyze the selection and use of specialized materials in electronics and computing, ensuring optimal functionality and efficiency in circuit design and component integration.	L4
4	Design and implement applications utilizing composite materials, considering their unique properties and manufacturing processes to optimize performance in industries like aerospace and automotive.	L4
5	Apply theoretical knowledge of material properties in practical scenarios to innovate and improve material selection and usage in engineering projects.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Callister, W. D., Jr., & Rethwisch, D. G. (2020). Materials Science and Engineering: An Introduction (10th ed.). Wiley.
2. Budinski, K. G., & Budinski, M. K. (2012). Engineering Materials: Properties and Selection (9th ed.). Prentice Hall.

Reference Books:

1. Ashby, M. F. (2017). Materials Selection in Mechanical Design (5th ed.). Butterworth-Heinemann.
2. Callister, W. D., Jr., & Rethwisch, D. G. (2020). Fundamentals of Materials Science and Engineering: An Integrated Approach (5th ed.). Wiley.

INDUSTRIAL ROBOTICS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand the fundamental principles, components, and classifications of industrial robots and their applications in various industries. 2. Develop the ability to analyze robot kinematics and dynamics for designing and optimizing robotic movements and tasks. 3. Acquire skills in programming industrial robots using various control strategies and understanding the integration of sensors and feedback mechanisms. 4. Apply knowledge of robotics to real-world industrial applications, focusing on automation in manufacturing and exploring robotics in non-traditional sectors. 5. Explore future trends in robotics, including the use of collaborative robots and the integration of artificial intelligence, to stay abreast of technological advancements.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction to Industrial Robotics	06 Hours
Overview of Industrial Robotics: History, evolution, and current trends in robotic technology. Types of Robots: Differentiate between articulated, SCARA, delta, and Cartesian robots based on structure and application areas. Robot Components: Detailed study of robot components including actuators, sensors, end-effectors, and controllers.	
UNIT – II: Robot Kinematics and Dynamics	10 Hours

Fundamentals of Kinematics: Introduction to kinematic chains, degrees of freedom, and robot motion analysis. Forward and Inverse Kinematics: Mathematical modeling to describe robot positions and orientations. Robot Dynamics: Understanding the forces and torques acting on robotic systems during movement.

UNIT - III: Robot Control Systems

10 Hours

Control Strategies: Overview of point-to-point control, continuous path control, and adaptive control.

Programming Robots: Introduction to robot programming languages and offline programming techniques. Sensors and Feedback: Role of sensors in robotics, sensor types, and their applications for feedback in robotic systems.

UNIT - IV: Applications of Industrial Robots

07 Hours

Robot Applications in Manufacturing: Automation of welding, assembly, painting, and material handling. Advanced Applications: Introduction to robots in non-manufacturing sectors such as healthcare, military, and service industries. Safety and Ergonomics: Understanding the safety protocols and human-robot interaction considerations in industrial settings.

UNIT - V: Future Trends and Innovations in Robotics

08 Hours

Collaborative Robots (Cobots): Exploring the capabilities and applications of cobots in industrial environments. Integration of AI and Machine Learning: How AI is being integrated into robotic systems to enhance functionality and decision-making. Sustainability and Robotics: Discussion on the environmental impact of robotics and sustainable practices in robot design and deployment.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply robotic kinematics and dynamics principles to design and implement effective robotic solutions for industrial applications.	L3
2	Program and control industrial robots using various programming languages and control systems to automate tasks effectively.	L3
3	Evaluate the integration of sensors and feedback systems in robotic applications to enhance operational accuracy and efficiency.	L3
4	Design and assess safety and ergonomic aspects of robot applications to ensure compliance with industry standards and enhance human-robot interaction.	L4
5	Implement collaborative robots and AI technologies in industrial settings, demonstrating an understanding of advanced robotics systems and their potential impacts.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Craig, J. J. (2017). *Introduction to Robotics: Mechanics and Control* (4th ed.). Pearson.
2. Mittal, R. K., & Nagrath, I. J. (2003). *Robotics and Control*. Tata McGraw-Hill Education.

Reference Books:

1. Janakiraman, P. A. (2009). *Robotics (Industrial Robotics)* (1st ed.). PHI Learning Pvt. Ltd.
2. Siciliano, B., & Khatib, O. (Eds.). (2016). *Handbook of Robotics* (2nd ed.). Springer.

Drives & Control systems [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code	:	Credits	03
Hours / Week	: 03 Hours	Total Hours	39 Hours
L-T-P-S	: 3-0-0-0		
Course Learning Objectives: This Course will enable students to: 1. Understand the fundamental principles and applications of various mechanical and electrical drive systems used in mechanical engineering. 2. Gain knowledge of power electronics including converters, inverters, and their role in drive systems. 3. Acquire skills in selecting and applying appropriate motor control techniques for different types of motors used in mechanical systems. 4. Learn to integrate hydraulic, pneumatic, and electrical control systems into mechanical designs for enhanced functionality. 5. Explore advanced control strategies and the latest technologies in drive systems to prepare for future challenges in mechanical engineering.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the realworld - and when that's possible, it helps improve the students' understanding.			
UNIT – I: Introduction to Drive Systems			09 Hours
Overview of Drive Systems: Role and types of drives in mechanical systems. Mechanical Drives: Study of belt, chain, and gear drives, focusing on their characteristics, applications, and selection criteria. Electrical Drives: Basics of electrical drive systems, including AC and DC drives,			

UNIT – II: Power Electronics in Drive Systems		09 Hours
Introduction to Power Electronics: Role of power electronics in controlling and driving mechanical systems. Semiconductor Devices: Thyristors, TRIACs, DIACs, and power transistors. Converters and Inverters: Basic circuits and their applications in drive systems, focusing on voltage and current control.		
UNIT – III: Electric Motor Control		06 Hours
Types of Motors: Induction, stepper, servo, and DC motors. Motor Starting Methods: Direct-on-line, star-delta, autotransformer, and electronic starters. Speed Control Methods: Various techniques for controlling motor speed, vector control and direct torque control.		
UNIT – IV: Control Systems for Mechanical Applications		07 Hours
Hydraulic and Pneumatic Control Systems: Components, circuit design, and applications. Control Strategies: Introduction to adaptive control, robust control, and predictive control. System Integration: Integrating control systems with mechanical components to create efficient, responsive mechanical systems.		
UNIT – V: Advanced Topics and Emerging Technologies		08 Hours
Regenerative and Energy Efficient Drives: Techniques and importance of energy efficiency in drive systems. Wireless and Remote Control of Drives: Technologies and applications in modern industry. Case Studies and Applications: Real-world applications and case studies focusing on innovative uses of drives and control systems in mechanical engineering.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply theoretical knowledge of different drive systems to evaluate and select suitable mechanisms for specific mechanical engineering applications.	L3
2	Design and analyze power electronic circuits used in drive systems to meet specified performance and efficiency criteria.	L3
3	Implement advanced motor control techniques for various types of electric motors, optimizing for performance and energy efficiency.	L3
4	Integrate diverse control systems, including hydraulic and pneumatic, into comprehensive mechanical system designs.	L4
5	Critically assess and adapt emerging drive technologies and control strategies to innovate and solve real-world mechanical engineering problems.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11		1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

Textbooks:

1. Hughes, A., & Drury, B. (2013). Electric Motors and Drives: Fundamentals, Types, and Applications (4th ed.). Elsevier.
2. Mohan, N., Undeland, T. M., & Robbins, W. P. (2003). Power Electronics: Converters, Applications, and Design (3rd ed.). Wiley.

Reference Books:

1. Sen, P. C. (2014). Principles of Electric Machines and Power Electronics (3rd ed.). Wiley.
2. Dorf, R. C., & Bishop, R. H. (2016). Modern Control Systems (13th ed.). Pearson.

MATERIALS FOR ADDITIVE MANUFACTURING [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code	:	Credits	03
Hours / Week	:	Total Hours	39 Hours
L-T-P-S	:	3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand the role and selection of various materials used in additive manufacturing. 2. Explore design and quality aspects related to additive manufacturing, including intellectual property and commercialization. 3. Study mathematical models and decision methods for optimizing additive manufacturing processes. 4. Investigate the applications of additive manufacturing in biomedical devices and other industries. 5. Learn advanced techniques and advancements in rapid manufacturing for polymeric, metallic, and ceramic objects.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the realworld - and when that's possible, it helps improve the students' understanding.			
UNIT – I : ROLE OF MATERIALS			09 Hours
Choosing Materials for Manufacturing, Multiple Materials, Metal AM Processes & Materials Composite Materials, Biomaterials, Hierarchical Materials & Bio mimetics, Ceramics & Bio-ceramics, Shape-Memory Materials, 4D Printing & Bio-active materials, Discussion on different materials used, multifunctional and graded materials in AM			

UNIT – II: Power Electronics in Drive Systems		06 Hours
Machines for Additive Manufacturing, Secondary Rapid Prototyping processes, Intellectual Property, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing. Design for AM (Build orientation, Topology optimization, Conformal cooling channels).		
UNIT – III: MATHEMATICAL MODELS IN AM		09Hours
Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation. Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Model validation for different criteria). Thermal cycle, Single bead and multi bead formation in cladding based AM processes		
UNIT – IV: ADDITIVE MANUFACTURING FOR BIO MEDICAL DEVICES & OTHERS		09 Hours
Bio microfluidics, Tissue Engineering. 3D Printing in Medicine, Computer Aided Design approach, medical research and clinical grade AM materials and AM fabrication methods Biomedical Applications, Direct Digital Manufacturing, Distributed Manufacturing, Mass Customization, , Aerospace & Automotive Applications, Architectural Engineering, Food & Consumer Applications, Personalized Surgery, Art, Fashion, Jewelry, Toys & Other Applications		
UNIT – V: RAPID MANUFACTURING OBJECTS		06 Hours
RM of polymeric objects, Direct and indirect routes for RM of metallic & ceramic objects, Advancement in RM (Synergistic integration of hybrid processes and multiple technologies). Smart materials.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze the selection and application of various materials used in additive manufacturing, including composites, biomaterials, ceramics, and shape-memory materials.	L3
2	Design additive manufacturing processes considering build orientation, topology optimization, and conformal cooling channels for improved product development and commercialization.	L3
3	Develop mathematical models for additive manufacturing processes to optimize part fabrication time, cost, and defect control.	L3
4	Evaluate the use of additive manufacturing in biomedical devices and other industries, focusing on specific applications and the advantages of AM methods.	L4

5	Implement rapid manufacturing techniques for polymeric, metallic, and ceramic objects, incorporating advancements in hybrid processes and smart materials.												L4	
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbooks:

1. Gibson, I., Rosen, D., & Stucker, B. (2020). Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing. Springer.
2. Zhou, K., & Wang, C. (2021). Additive Manufacturing: Materials, Processes, Quantifications and Applications. Elsevier.

Reference Books:

1. Srivatsan, T. S., & Sudarshan, T. S. (2015). Additive Manufacturing: Innovations, Advances, and Applications. CRC Press.
2. Chua, C. K., & Leong, K. F. (2017). 3D Printing and Additive Manufacturing: Principles and Applications (5th ed.). World Scientific.

AUTOTRONICS			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code :		Credits	: 03
Hours/Week : 03 Hours		Total Hours	:
39Hours			
L-T-P-S :		3-0-0-0	
Course Learning Objectives:			
This course will enable students to:			
1. Understand the significance of autotronics in modern vehicles. 2. Learn the basics of automotive electronics, sensors, and ECUs. 3. Master automotive communication systems and diagnostic protocols. 4. Gain expertise in engine management and advanced driver-assistance systems. 5. Explore hybrid and electric vehicle technologies, and future trends in automotive electronics			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.			
• Lecture method means it includes not only traditional lecture method but different <i>types of teaching methods</i> that may be adopted to develop the course outcomes. • Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. • Show Video/animation films to explain the functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher-order Thinking questions in the class. • Adopt Problem-Based Learning, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding. • Practical experimentation of material testing of different metals and alloys			
Unit-1: Introduction to Autotronics			8 Hours

Overview of Autotronics and its significance in modern vehicles. Basic electronics and electrical systems in automobiles. Sensors and actuators: Types, working principles, and applications. Electronic control units (ECUs): Functionality and architecture.	
Unit-2: Automotive Communication Systems	8 Hours
In-vehicle networking: CAN, LIN, MOST, and FlexRay protocols. Data transmission and communication standards in automobiles. Diagnostics and On-Board Diagnostics (OBD) systems Real-time operating systems and software for automotive applications.	
Unit-3: Engine Management Systems	8 Hours
Electronic Fuel Injection (EFI) systems: Components and operation. Ignition systems: Types, working principles, and control strategies. Exhaust gas recirculation and emission control technologies. Advanced driver-assistance systems (ADAS): Functions and integration.	
Unit-4: Hybrid and Electric Vehicle Technology:	8 Hours
Basics of hybrid and electric powertrains. Battery management systems: Monitoring, control, and safety. Regenerative braking systems and energy recovery. Power electronics in hybrid and electric vehicles: Inverters, converters, and controllers.	
Unit-5: Advanced Topics in Autotronics:	7 Hours
Autonomous vehicles: Sensors, algorithms, and control systems. Vehicle-to-everything (V2X) communication and connectivity. Advanced safety systems: Collision avoidance, adaptive cruise control, and lane-keeping assistance. Future trends in automotive electronics: AI and machine learning in vehicles.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze and evaluate the functionality and architecture of Electronic Control Units (ECUs) within modern automotive systems to optimize vehicle performance.	L3
2	Assess and implement automotive communication protocols such as CAN, LIN, MOST, and FlexRay to enhance in-vehicle networking and diagnostic capabilities.	L3
3	Design and manage advanced engine management systems, including Electronic Fuel Injection (EFI) and ignition control strategies, to improve fuel efficiency and emission control.	L3
4	Develop and integrate hybrid and electric vehicle technologies, focusing on battery management systems, regenerative braking, and power electronics to enhance vehicle sustainability and performance.	L4

5	Investigate and apply advanced topics in autotronics such as autonomous vehicle technologies, V2X communication, and AI-driven safety systems to advance future automotive innovations.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Navet, N., & Simonot-Lion, F. (2017). Automotive Embedded Systems Handbook. CRC Press.
2. Ribbens, W. (2017). Understanding Automotive Electronics. Elsevier.

Reference Books:

1. Reif, K. (2014). Automotive Mechatronics: Automotive Networking, Driving Stability Systems, Electronics. Springer.
2. Mi, C., Masrur, M. A., & Gao, D. W. (2017). Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives. Wiley.

WIND ENERGY SYSTEMS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Comprehend the basic principles of wind energy conversion and the components of wind turbines 2. Optimize blade designs and understand advanced aerodynamic effects on turbine efficiency 3. Understand the dynamic loads and structural behavior of wind turbines 4. Implement control systems to enhance wind turbine performance and grid stability 5. Explore the unique challenges of offshore wind energy systems, including design and maintenance.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding. •	
UNIT – I : FUNDAMENTALS OF WIND ENERGY AND RESOURCE	06 Hours
Overview of wind energy as a renewable resource. Historical development and current trends in wind energy. Basic components and functioning of wind turbines. Wind characteristics: speed, direction, and variability. Methods for measuring and estimating wind resources. Criteria for selecting wind farm sites and optimizing layout.	
UNIT – II: WIND TURBINE AERODYNAMICS AND PERFORMANCE:	08 Hours

Airfoil characteristics and aerodynamic forces, Blade Element Momentum (BEM) theory. Power coefficient and its significance in wind turbine design, 3D aerodynamic effects and tip loss corrections, Dynamic stall and its impact on turbine blade performance. Aerodynamic optimization of wind turbine blades, Standards and processes for turbine performance testing, Power curve measurement and interpretation, Certification procedures and compliance requirements.

UNIT - III: STRUCTURAL DYNAMICS AND DESIGN OF WIND TURBINES	07 Hours

Load analysis: aerodynamic, gravitational, and inertial forces, Natural frequencies, mode shapes, and resonance in turbine structures, Dynamic response and vibration analysis of turbine components,

Fatigue life prediction and load spectrum analysis, Structural health monitoring systems and strategies, Design for reliability and mitigation of fatigue-induced failures, Material properties and selection criteria for wind turbine components.

UNIT - IV: ELECTRICAL POWER CONVERSION AND GRID INTEGRATION	09 Hours

Types of wind turbine generators and power electronics, Power conversion and transmission systems in wind turbines, Challenges and strategies for integrating wind power into electrical grids, Role of energy storage in wind energy systems, Types of energy storage technologies: batteries, flywheels, pumped hydro, Hybrid systems combining wind power with other renewable sources.

UNIT - V: OFFSHORE WIND ENERGY AND FUTURE TRENDS	06 Hours

Design and deployment challenges unique to offshore wind, Structural design of offshore wind turbines and floating platforms, Installation, operation, and maintenance of offshore wind farms, Recent advancements in wind turbine technology and materials. Emerging technologies: floating turbines, airborne wind energy, bladeless turbines, Future trends and potential developments in wind energy research and deployment.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Assess and interpret wind resource data to determine optimal sites for wind farm development	L3
2	Analyze the aerodynamic forces acting on wind turbine blades using the Blade Element Momentum (BEM) theory. Optimize blade designs for enhanced efficiency through advanced aerodynamic principles.	L3
3	Design wind turbine components considering material properties, structural integrity, and fatigue life	L3
4	Develop and simulate control algorithms to optimize the performance and stability of wind turbines. Analyze the electrical power conversion processes and solve challenges related to grid integration of wind power.	L4
5	Evaluate the unique design, deployment, and maintenance challenges associated with offshore wind energy systems.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	2	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbook:

1. Sørensen, J. D., & Sørensen, J. N. (2010). Wind Energy Systems. Woodhead Publishing.

Reference Books:

1. Centre for Wind Energy Technology (C-WET). Wind Energy Resources Survey in India. [No further details on publisher or publication year available for an accurate APA citation.]
2. Kaldellis, J. K. (2010). Stand-alone and Hybrid Wind Energy Systems. CRC Press.

E-Resources:

1. https://archive.nptel.ac.in/content/storage2/courses/108108078/pdf/chap6/teach_slides06.pdf
2. <https://archive.nptel.ac.in/courses/103/103/103103206/>

MEMS (MICRO ELECTRO MECHANICAL SYSTEMS) [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Introduce the fundamentals, design, and applications of MEMS technology. 2. Understand the properties and uses of various substrate materials and wafers in MEMS. 3. Learn the different fabrication processes used in MEMS manufacturing. 4. Explore the principles and applications of various types of micro sensors. 5. Study the design and functioning of microactuators and their systems.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction to MEMS	06 Hours
Definition – development- fundamentals of MEMS. Micro fluidics, microelectronics, micro systems- design and fabrication, working principles and applications. Integrated circuit processes, potential of MEMS in industry	
UNIT – II: Substrates and Wafers	08 Hours
Materials substrates and wafers, silicon substrate- properties of silicon, silicon compounds, silicon piezo resistors. Gallium Arsenide, quartz, polymer for MEMS, conductive polymer. Shape memory alloys.	
UNIT – III: Fabrication Processes	07 Hours

Photolithography, photo resist applications, light sources, X-ray lithography, electron beam lithography, ion implantation, thin film deposition, diffusion process, Chemical and physical vapour deposition, bulk and surface machining, LIGA, laser ablation process. Micro steriolithography for 3D fabrication and nanolithography.

UNIT – IV: Sensors		06 Hours
Micro sensors, classification of physical sensors, integrated, intelligent or smart sensors, sensors principle, thermal sensors, electrical sensors, mechanical sensors, chemical and biosensors.		
UNIT – V: Microactuators		09 Hours
Electromagnetic and thermal microactuation, mechanical design of micro actuators, microactuator, micro valves, micro pumps, micro motors. Microactuator systems: Ink jet printers, micro-mirror TV projectors. Micro-opto- electromechanical systems, metal oxide semiconductor field effect transistor, multi-disciplinary applications.		

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Analyze the fundamentals, design, and fabrication processes of MEMS and their applications in various industries.	L3												
2	Evaluate the properties and applications of different substrate materials and wafers used in MEMS, including silicon and shape memory alloys.	L3												
3	Apply various MEMS fabrication processes such as photolithography, ion implantation, and thin film deposition to create microsystems.	L3												
4	Classify and assess the principles and applications of different types of micro sensors, including thermal, electrical, mechanical, chemical, and biosensors.	L4												
5	Design and implement microactuator systems for various applications, including electromagnetic and thermal microactuation, micro valves, micro pumps, and micro motors.	L4												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	2	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Senturia, S. D. (2000). Microsystem Design. Kluwer Academic Publishers.
2. Liu, C. (2011). Foundations of MEMS. Prentice Hall.

Reference Books:

1. Maluf, N., & Williams, K. (2004). Introduction to Microelectromechanical Systems Engineering (2nd ed.). Artech House.
2. Korvink, J. G., & Paul, O. (2005). MEMS: A Practical Guide of Design, Analysis, and Applications. Springer.

Professional Elective-III

Robot Kinematics and Dynamics [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L–T–P–S	: 3–0–0–0		
Course Learning Objectives: This Course will enable students to: 1. Deepen understanding of coordinate systems, transformations, and frame representations specifically applied to robotic systems. 2. Develop proficiency in analyzing and solving both forward and inverse kinematics problems for various types of robotic manipulators. 3. Enhance skills in calculating and interpreting differential motions and velocities in robotic systems to optimize operational efficiency. 4. Master dynamic modeling techniques, including Newton-Euler and Lagrangian methods, to accurately predict forces and motions in robotic mechanisms. 5. Explore advanced topics and current research trends in robot kinematics and dynamics to prepare for innovative problem-solving in robotics engineering.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Introduction to Robotic Systems			09 Hours
Overview of Robotics: Types of robots and their applications. Coordinate Systems and Transformations: Frame representations, homogeneous coordinates, and transformation matrices specific to robotic applications. Review of Basic Kinematics and Dynamics: A brief recap			

emphasizing aspects uniquely applicable to robotic systems.

UNIT – II: Forward and Inverse Kinematics of Robots

09 Hours

Forward Kinematics: Derivation of position and orientation for robotic manipulators. Inverse Kinematics: Solution techniques for position and orientation determination of the end-effector. Workspace Analysis: Determination of reachable spaces and dexterous workspaces in robotic systems. Jacobian and Singularities: Understanding the role of the Jacobian matrix in velocity and force analysis, and identifying singular configurations.

UNIT – III: Differential Motions and Velocities

**06
Hours**

Differential Relationships: Mapping from joint velocities to end-effector velocities. Motion Trajectories: Planning and analysis of trajectories in joint space and Cartesian space for robots. Velocity Kinematics: Analysis of velocities within the context of robot manipulators and the implications of different configurations.

UNIT – IV: Robot Dynamics

**07
Hours**

Dynamic Modeling and Equation Derivation: Application of Newton-Euler and Lagrangian methods to robotic systems. Forces and Torques: Computation for static and dynamic cases in robotic arms. Energy Methods in Robotics: Application of energy conservation principles to the analysis and simulation of robotic motion.

UNIT – V: Advanced Topics in Robot Kinematics and Dynamics

**08
Hours**

Multi-body Dynamics: Analysis of complex robotic systems with multiple interconnected bodies. Nonlinear Dynamics of Robots: Study of behavior under non-linear conditions and impacts. Introduction to Computational Dynamics: Use of software tools for simulation and analysis of robotic kinematics and dynamics. Current Trends and Research in Robotic Kinematics and Dynamics: Discussion of recent advancements and future directions in the field.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply transformation matrices and coordinate system techniques to model complex robotic systems and solve spatial relationship problems.	L2 & L3
2	Design and execute kinematic analyses to determine the position, orientation, and trajectory of robot manipulators in both forward and inverse configurations.	L2 & L3
3	Utilize differential kinematics and dynamics to analyze and optimize the velocity and acceleration profiles of robotic systems during operation.	L3

4	Construct dynamic models of robots using advanced mathematical methods and validate these models through computational simulations to predict real-world behavior.	L4
5	Critically assess and integrate current research and technological advances in robot kinematics and dynamics into practical applications and academic discussions.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2009). Robotics: Modelling, Planning and Control. Springer.
2. Craig, J. J. (2017). Introduction to Robotics: Mechanics and Control (4th ed.). Pearson.

Reference Books:

1. Spong, M. W., & Vidyasagar, M. (2008). Robot Dynamics and Control (2nd ed.). Wiley.
2. Angeles, J. (2014). Fundamentals of Robotic Mechanical Systems: Theory, Methods, and Algorithms (4th ed.). Springer.

PROCESSING OF PLASTICS AND COMPOSITES [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VI			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L–T–P–S	: 3–0–0–0		
Course Learning Objectives: This Course will enable students to: 1. Understand the properties, classifications, and applications of various plastics and composite materials. 2. Learn and apply different processing techniques for manufacturing plastic products, focusing on process parameters and quality. 3. Explore and implement various composite processing techniques, ensuring process optimization and quality control. 4. Investigate advanced processing methods, including additive manufacturing and hybrid techniques, for plastics and composites. 5. Conduct mechanical and non-destructive testing, thermal analysis, and quality control procedures for plastics and composites, adhering to industry standards.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Introduction to Plastics and Composites			07 Hours
Overview of plastics and composites, Classification and types of plastics, Types of composite materials, Basic properties and applications, Advantages and limitations			
UNIT – II: Processing Techniques for Plastics			07 Hours

Injection molding, Extrusion, Blow molding, Thermoforming, Rotational molding, Process parameters and their effects on product quality	
UNIT – III: Processing Techniques for Composites	08 Hours
Hand lay-up and spray-up, Filament winding, Pultrusion, Resin transfer molding (RTM), Compression molding, Autoclave and out-of-autoclave processing, Process parameters and quality control	
UNIT – IV: Advanced Processing Methods	09 Hours
Additive manufacturing for plastics and composites, Advanced injection molding techniques, Vacuum-assisted resin infusion, Automated fiber placement (AFP) and automated tape laying (ATL), Hybrid processing techniques, Nano-composites processing	
UNIT – V: Testing and Quality Control	08 Hours
Mechanical testing of plastics and composites, Non-destructive testing methods, Thermal analysis and characterization techniques, Quality control in manufacturing processes, Standards and specifications for plastics and composites, Case studies on quality control and failure analysis	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze the properties and applications of various plastics and composite materials.	L3
2	Apply different processing techniques for manufacturing plastic products, considering process parameters and product quality.	L3
3	Implement various composite processing techniques, ensuring quality control and understanding process parameters.	L3
4	Explore advanced processing methods for plastics and composites, including additive manufacturing and hybrid techniques.	L4
5	Conduct testing and quality control procedures for plastics and composites, utilizing appropriate standards and specifications.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Crawford, R. J., & Throne, J. L. (2012). Plastics Engineering (3rd ed.). Butterworth-Heinemann.
2. Chawla, K. K. (2012). Composite Materials: Science and Engineering (3rd ed.). Springer.

Reference Books:

1. Muccio, E. A. (1994). Understanding Plastics Engineering and Manufacturing: A Practical Guide. Hanser Gardner Publications.
2. Gibson, R. F. (2016). Principles of Composite Material Mechanics (4th ed.). CRC Press.

AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject Code	:	Credits	: 03
Hours/Week	: 03 Hours	Total Hours	:
39Hours			
L-T-P-S	:	3-0-0-0	
Course Learning Objectives: This course will enable students to: 1. Introduce the fundamental concepts and functions of automotive chassis systems. 2. Explain the design and operational principles of various suspension systems. 3. Describe the mechanics and components of different steering systems. 4. Provide an understanding of drivetrain and transmission system layouts and functions. 5. Explore advanced technologies in differentials and their impact on vehicle performance.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method but different <i>types of teaching methods</i> that may be adopted to develop the course outcomes. Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. Show Video/animation films to explain the functioning of various concepts. Encourage Collaborative (Group Learning) Learning in the class. To make Critical thinking , ask at least three Higher-order Thinking questions in the class. Adopt Problem-Based Learning , which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding.			
Unit-1: Introduction to Automotive Chassis Systems			8 Hours

Overview of Automotive Chassis: Definition and functions, Types of chassis layouts (body-on-frame, monocoque). Materials Used in Chassis Construction: Types of materials (steel, aluminum, composites), Material properties and selection criteria. Design Considerations: Load distribution and structural integrity, Safety regulations and standards. Chassis Components: Frame, subframe, and cross members, Design and manufacturing processes		
Unit-2: Suspension Systems		7 Hours
Introduction to Suspension Systems: Purpose and function of suspension, Types of suspension systems (dependent, independent). Suspension Geometry: Camber, caster, toe, and their effects on vehicle dynamics, Suspension kinematics Suspension Components: Springs (coil, leaf, torsion bar), Dampers (shock absorbers, struts), Anti-roll bars and bushings. Advanced Suspension Technologies: Active and semi-active suspension systems, Air suspension and electronic control systems		
Unit-3: Steering Systems		7 Hours
Fundamentals of Steering Systems: Types of steering mechanisms (manual, power-assisted), Rack and pinion, recirculating ball, and worm gear steering. Steering Geometry and Alignment: Ackermann principle, Understeer and oversteer, Wheel alignment (toe, camber, caster). Steering System Components: Steering wheel, column, and rack, Power steering pumps and hoses, Sensors and electronic control units (ECUs). Modern Steering Technologies: Electric power steering (EPS), Four-wheel steering, Steer-by-wire systems		
Unit-4: Drivetrain and Transmission Systems		8 Hours
Overview of Drivetrain Systems: Layouts (FWD, RWD, AWD, 4WD), Function and importance of drivetrain components. Clutches and Torque Converters: Types of clutches (single plate, multi-plate, centrifugal), Torque converter operation and components. Manual Transmission Systems: Gearbox design and operation, Synchronizers and shift mechanisms, Types of manual transmissions (synchromesh, constant mesh). Automatic Transmission Systems: Types of automatic transmissions (traditional, CVT, DCT), Hydraulic systems and electronic control units, Transmission fluid and cooling		
Unit-5: Final Drive and Differential Systems		9 Hours
Introduction to Final Drive: Purpose and function of the final drive, Types of final drive systems (front, rear, all-wheel drive). Differential Systems: Open, limited-slip, and locking differentials, Planetary gear sets and operation. Axles and Driveshafts: Design and construction of axles, Driveshaft components and balancing. Advanced Differential Technologies: Electronic limited-slip differentials (eLSD), Torque vectoring systems, Impact of differentials on handling and performance.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		

1	Apply principles of chassis design to evaluate and improve vehicle structural integrity and safety.	L3
2	Analyze suspension system components and geometries to enhance vehicle ride comfort and handling performance.	L3
3	Design and troubleshoot various steering systems to ensure optimal vehicle steering response and control.	L3
4	Implement and optimize drivetrain and transmission systems to achieve desired vehicle performance and efficiency.	L4
5	Integrate advanced differential technologies to improve vehicle traction and stability under various driving conditions.	L4

**Table: Mapping Levels of COs to POs /
PSOs**

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Birch, T. W. (2019). Automotive Chassis Systems (6th ed.). Pearson.
2. Gillespie, T. D. (1992). Fundamentals of Vehicle Dynamics. SAE International.

Reference Books:

1. Naunheimer, H., et al. (2010). Automotive Transmissions: Fundamentals, Selection, Design and Application (2nd ed.). Springer.
2. Adams, H. (1992). Chassis Engineering: Chassis Design, Building & Tuning for High Performance Handling. HP Books.

HYDROGEN ENERGY AND STORAGE [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VI	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Describe historical developments and current advancements in hydrogen technologies. Identify the unique properties of hydrogen relevant to its use as a fuel. 2. Analyze various production methods such as steam methane reforming, electrolysis, and biomass conversion 3. Identify key components of hydrogen distribution systems, including pipelines and refueling stations. 4. Describe the working principles and components of various types of fuel cells 5. Conduct life cycle assessments to evaluate the environmental footprint of hydrogen production, storage, and utilization.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I: OVERVIEW OF HYDROGEN ENERGY:	06 Hours
History and development of hydrogen technologies, Hydrogen as an energy carrier in modern energy systems, Global energy challenges and the role of hydrogen, Physical and chemical properties of hydrogen, Hydrogen's advantages and challenges as a fuel, Safety considerations in handling hydrogen,	
UNIT – II: HYDROGEN PRODUCTION TECHNOLOGIES:	08 Hours
Conventional Hydrogen Production, Steam Methane Reforming (SMR) and Partial Oxidation. Coal Gasification and other fossil fuel-based methods, Water Electrolysis (Alkaline, PEM, SOEC).	

Biological and Photolytic production processes, Thermochemical cycles, Novel methods and future trends in hydrogen production, Hydrogen production from biomass and waste materials.

UNIT – III: HYDROGEN STORAGE AND DISTRIBUTION		09 Hours
Compressed Gas and Liquid Hydrogen Storage, Cryo-compressed hydrogen storage, Solid-state storage (Metal Hydrides, Chemical Hydrides), Carbon-based storage materials and other novel methods, Material considerations and safety in hydrogen storage. Hydrogen distribution systems: Pipelines, trucking, and shipping, Infrastructure requirements for hydrogen refueling stations, Technological challenges and solutions in hydrogen logistics, Economic feasibility and scalability of hydrogen distribution networks		
UNIT – IV : FUEL CELL TECHNOLOGIES AND APPLICATIONS		07 Hours
Fundamentals of fuel cells: PEMFC, SOFC, MCFC, etc, Components and operation of fuel cells. Applications of fuel cells in transport, stationary power, and portable devices, Efficiency analysis and comparison with conventional energy systems.		
UNIT – V		06 Hours
Evaluate the financial viability and market potential of hydrogen technologies, including production, storage, and distribution, using economic modeling and cost-benefit analysis frameworks		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze the significance of hydrogen as an energy carrier in the context of global energy demands. Formulate safety protocols and strategies for handling hydrogen based on its properties.	L3
2	Evaluate and justify the selection of hydrogen production methods based on efficiency, environmental impact, and scalability	L3
3	Analyze and compare the various hydrogen storage technologies, including compressed gas, liquid hydrogen, cryo-compressed hydrogen, solid-state storage (metal hydrides and chemical hydrides), and carbon-based storage materials.	L3
4	Evaluate and differentiate the operational principles and characteristics of different types of fuel cells, including Proton Exchange Membrane Fuel Cells (PEMFC), Solid Oxide Fuel Cells (SOFC), and Molten Carbonate Fuel Cells (MCFC). Assess the economic viability and lifecycle costs of deploying fuel cell technologies across different applications compared to traditional energy solutions	L4
5	Evaluate the financial viability and market potential of hydrogen technologies, including production, storage, and distribution, using economic modeling and cost-benefit analysis frameworks also Assess the environmental impacts of hydrogen energy systems through life cycle assessments (LCA), focusing on their carbon footprint and resource utilization	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

TEXT BOOKS:

1. Bent Sørensen and Giuseppe Spazzafumo (2018), Hydrogen and Fuel Cells, Woodhead Publishing, Elsevier Science
2. Paul Ekins(2010), Hydrogen Energy, Earthscan

REFERENCE BOOKS:

1. Detlev Stolten (2011), Hydrogen and Fuel Cells. Fundamentals, Technologies and Applications, Wiley, John & Sons

E-Resources:

1. https://onlinecourses.nptel.ac.in/noc22_ch66/preview
2. <https://nptel.ac.in/courses/103101215>

TOTAL QUALITY MANAGEMENT [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Subject code	Credits	:	03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-S	:	3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. To understand the fundamental principles and concepts of Total Quality Management (TQM) and their application in improving organizational performance. 2. To gain proficiency in the use of statistical tools and techniques for quality control and improvement. 3. To develop the ability to analyze and evaluate quality management systems and identify opportunities for continuous improvement. 4. To learn how to design and implement quality plans that align with customer expectations and organizational goals. 5. To acquire knowledge of international quality standards and frameworks, and how to apply them to achieve certification and enhance quality assurance processes.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Introduction to Quality Management			06 Hours
Concepts of Quality: Definitions and dimensions of quality, Evolution of quality management, Quality gurus: Deming, Juran, Crosby, Feigenbaum. Principles of Total Quality Management (TQM): Customer focus, Continuous improvement (Kaizen),			

Employee involvement and empowerment. TQM Framework: TQM models: Deming's 14 points, Juran's Trilogy, Crosby's Quality Management Maturity Grid

UNIT – II: Quality Planning and Control		07 ours
Quality Planning : Quality policy and objectives, Strategic quality planning, Quality function deployment (QFD) .Quality Control Tools: Statistical process control (SPC), Control charts for variables and attributes, Process capability analysis. Quality Improvement Techniques: PDCA cycle (Plan-Do-Check-Act), Six Sigma methodology, Lean principles and waste reduction.		
UNIT – III: Quality Assurance and Standards		08 Hours
Quality Assurance (QA): Concepts and importance of QA, QA in design and development, QA in manufacturing and services. Quality Management Systems (QMS): ISO 9001 standards, Implementation and certification process, Auditing and documentation. Advanced Quality Management Standards: ISO 14000 (Environmental Management), ISO 45000 (Occupational Health and Safety), ISO/TS 16949 (Automotive Quality Management).		
UNIT – IV : Tools and Techniques for Quality Improvement		07 Hours
Problem Solving and Decision Making: Root cause analysis, Failure mode and effects analysis (FMEA), Design of experiments (DOE). Quality Improvement Tools: Pareto analysis, Fishbone diagram (Ishikawa), Flowcharts and process mapping. Benchmarking and Best Practices: Types of benchmarking, Steps in benchmarking process, Case studies of successful quality improvement		
UNIT – V: Quality Management in Practice		06 Hours
Quality in Manufacturing: Total productive maintenance (TPM), Just-in-time (JIT) and Kanban systems, Statistical quality control (SQC). Quality in Services: Service quality dimensions (SERVQUAL), Quality in healthcare, education, and hospitality, Customer satisfaction and feedback mechanisms. Future Trends in Quality Management: Quality 4.0 and digital transformation, Role of big data and analytics in quality, Sustainable quality management practices.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply statistical process control (SPC) techniques to monitor and control manufacturing processes, ensuring product quality and consistency.	L3
2	Analyze quality management systems (QMS) to identify areas for improvement and develop strategies for enhancing overall system performance.	L3
3	Evaluate various quality improvement methodologies such as Six Sigma and Lean principles to determine their	L3

	effectiveness in different industrial contexts.	
4	Design comprehensive quality plans that integrate quality function deployment (QFD) and other planning tools to meet customer requirements and organizational goals.	L4
5	Implement advanced quality assurance protocols and standards, including ISO 9001, to achieve and maintain certification and continuous quality improvement in manufacturing and service processes.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Besterfield, D. H. (2018). Total Quality Management (5th ed.). Pearson.
2. Goetsch, D. L., & Davis, S. (2016). Quality Management for Organizational Excellence: Introduction to Total Quality (8th ed.). Pearson.

Reference Books:

1. Evans, J. R., & Lindsay, W. M. (2014). The Management and Control of Quality (8th ed.). Cengage Learning.
2. Juran, J. M. (2010). Juran's Quality Handbook (6th ed.). McGraw-Hill Education.

FUNDAMENTALS OF ECONOMICS [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Realize importance of Fundamentals of economics in Engineering. 2. Comprehend the ideas of Time value of money and Inflation. 3. Explain Present worth and equivalent annual worth calculations 4. Demonstrate Economic planning and finance commission and its importance 5. Recognize the importance of taxation, RBI and its monetary operations and public finance	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours

Introduction to Engineering economics, Engineering decision makers, engineering and economics, problem solving and decision making, strategy and tactics, factors of production, Production possibility schedule and curve, marginal rate of transformation, Concept of economic growth. (Text Book-1: Chapter 1: 1.1 to 1.4, Chapter 2: 2.1 to 2.4)	
UNIT – II	08 Hours
Time value of money - Simple interest, compound interest – nominal interest rate, effective interest rate, and inflation. (Text Book-1: Chapter 2: 2.1-2.7).	
UNIT – III	07 Hours
.Present worth calculations, Equivalent Annual worth Comparison methods, Situations for Equivalent Annual worth Comparison, Consideration of asset life, comparison of assets with equal and unequal lives. (Text Book-1: Chapter 3: 3.1 to 3.5)	
UNIT – IV	08 Hours
Economic Planning- Regional planning, National planning and Inclusive development. Planning in India- Vishveshwaraiah Plan, Bombay Plan, Gandhian Plan, Harrod Domar plan, Main objectives of Planning, Relevance of Planning in Economic reforms of the Nation, Five year plans, Finance commission and its functions (Text Book-2: Chapter 4: 4.4 to 4.6, Chapter- 5: 5.2,5.5, to 5.7, 5.19- 5.27, 5.33, 5.38,)	
UNIT – V	08 Hours
The idea of National income- GDP, GNP, NDP and NNP, Types of economic sectors- primary, secondary and tertiary, Reserve Bank of India and its Monetary operations, Tax structure in India and GST, Public Finance in India- Budgetary terms (Text Book-2: Chapter 1: 1.13, 1.14- 1.17, Chapter 12: 12.4- 12.8, Chapter 17: 17.3-17.4, 17.7)	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the principles of engineering economics to make informed engineering decisions, considering both economic and technical factors.	L3
2	Analyze the impact of time value of money on engineering projects, calculating present and future values using simple and compound interest, nominal and effective interest rates, and accounting for inflation.	L3
3	Evaluate various economic alternatives using present worth and equivalent annual worth comparison methods, taking into account asset life and the comparison of assets with equal and unequal lives.	L3
4	Design economic plans at regional and national levels by understanding and applying different planning strategies, such as the Vishveshwaraiah Plan, Bombay Plan, Gandhian Plan, and Harrod Domar plan, and by evaluating the relevance of these plans in the	L4

	context of economic reforms.	
5	Implement knowledge of national income concepts (GDP, GNP, NDP, and NNP) and the structure of economic sectors to assess the economic environment, understand the role of the Reserve Bank of India, analyze the tax structure and GST, and interpret budgetary terms in the context of public finance in India.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	3	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. Riggs, J., Bedworth D., & Randhawa S., (2011), **Engineering Economics**, 4th Edition, McGraw-Hill Education.
2. Ramesh Singh., (2023-24), Indian Economy, 15th Edition, McGraw- Hill Publications

REFERENCE BOOKS:

1. Panneerselvam R, (2013), **Engineering Economics**, 2nd edition, Prentice Hall India Learning Private Limited

INSTRUMENTATION AND CONTROL [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 04 Hours	Total Hours : 26+26Hours
L-T-P-S : 2-0-2-0	
Course Learning Objectives: This course provides an introduction to the fundamental concepts of instrumentation and control engineering. It is designed for undergraduate students and covers essential topics in instrumentation and basic control systems, ensuring students gain foundational knowledge. 1. Explain the operating principles of various measurement systems and how they apply to engineering problems. 2. Describe the fundamental roles of sensors, transducers, and signal conditioning in instrumentation systems 3. Illustrate the basic structure and function of control systems through examples and mathematical models. 4. Evaluate control system performance using time-domain and frequency-domain analysis techniques. 5. Apply control theories and methods to design simple control systems for practical engineering applications.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. - Show Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, ask at least three Higher order Thinking questions in the class. - Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it. - Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every concept can be applied to the real world - and when that's possible, it helps improv the students' understanding.	
UNIT – I Introduction to Instrumentation	09 Hours
Introduction to Instrumentation, Overview of instrumentation in engineering. Importance and applications in various systems. SI units and standards in measurement. Importance of accuracy and calibration	

UNIT – II: Basic Components of Instrumentation		09 ours
Sensors and Transducers Types and working principles of sensors (e.g., temperature, pressure, force. Applications in different engineering fields. Signal processing: filters, amplifiers, and converters. Importance of noise reduction and data accuracy.		
UNIT – III: Introduction to Control Systems		08 Hours
Basics of Control Systems, Introduction to open-loop and closed-loop control systems. Examples in engineering (e.g., temperature, speed control). Mathematical Modelling of Control Systems Transfer functions and block diagrams. Modelling of engineering systems (e.g., mass-spring-damper, fluid systems).		
UNIT – IV: Analysis of Control Systems		08 Hours
Frequency-Domain Analysis Frequency response analysis using Bode plots. Interpretation of frequency response characteristics. Time-Domain Analysis of transient and steady-state responses. Time-domain specifications (rise time, settling time, overshoot).		
UNIT – V: Basic Design of Control Systems		06 Hours
PID Controllers Application of Proportional, Integral, and Derivative controllers. Tuning methods and practical considerations. Stability and Performance Stability analysis using root locus and other techniques. Design for stability and performance in control applications Case studies in various engineering systems (e.g., vibration control, thermal systems).		

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Apply the principles of instrumentation to select and utilize appropriate sensors and transducers for measuring physical quantities (e.g., temperature, pressure, force) in diverse engineering applications.	L1												
2	Analyze signal processing components, such as filters, amplifiers, and converters, to enhance noise reduction and data accuracy in measurement systems.	L2												
3	Evaluate the performance of control systems by constructing and interpreting mathematical models using transfer functions and block diagrams, and differentiating between open-loop and closed-loop systems.	L3												
4	Design control systems by conducting frequency-domain and time-domain analysis, utilizing techniques like Bode plots and transient response analysis to meet specific performance criteria (e.g., rise time, settling time, overshoot).	L2												
5	Implement and tune PID controllers in practical engineering scenarios, employing stability analysis methods such as root locus to ensure optimal control system performance and stability in applications like vibration control and thermal systems.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	2	3	1	1	1	2	2	1	1	3	3

C02	3	3	3	2	3	1	1	1	2	2	1	1	3	3
C03	3	3	3	2	3	1	1	1	2	2	1	1	3	3
C04	3	3	3	2	3	1	1	1	2	2	1	1	3	3
C05	3	3	3	2	3	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Nakra, B. C., & Chaudhary, K. K. (2003). Instrumentation, Measurement and Analysis (3rd ed.). McGraw-Hill Education.
2. Nagrath, I. J., & Gopal, M. (2009). Control Systems Engineering (5th ed.). New Age International Publishers. ISBN: 9788122420080.

Reference Books:

1. Ogata, K. (2009). Modern Control Engineering (5th ed.). Prentice Hall.
2. Doebelin, E. O. (2004). Measurement Systems: Application and Design (5th ed.). McGraw-Hill Education.

OPEN ELECTIVE-2

AUTOMOBILE ENGINEERING [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand the basic principles of automobile engineering, including vehicle dynamics, propulsion systems, and the integration of mechanical components. 2. Develop a comprehensive understanding of electric vehicles, including their architecture, key components, and the underlying electrical systems. 3. Acquire knowledge of hybrid technologies and advanced propulsion systems, focusing on their design, functionality, and environmental impact. 4. Gain insights into advanced driver-assistance systems (ADAS), exploring their technological foundations, operational mechanisms, and benefits. 5. Explore the design considerations, safety standards, and regulatory requirements applicable to modern automobiles, particularly electric and hybrid vehicles.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Fundamentals of Automobile Engineering	06 Hours
Overview of Automobile Systems: Introduction to the various systems in automobiles such as chassis, transmission, engine, braking, and steering systems. Automotive Materials and Manufacturing Processes: Study of materials used in automotive manufacturing, including emerging materials for lightweight construction.	
UNIT – II: Electric Vehicles (EVs)	10 Hours

Introduction to Electric Vehicles: History and evolution of EVs, comparison with internal combustion engine vehicles. EV Architecture and Systems: Detailed study of electric vehicle components including batteries, electric motors, controllers, and regenerative braking systems. Battery Technology and Management Systems: Types of batteries used in EVs, battery management systems, charging technologies, and strategies for enhancing battery life.

UNIT – III: Hybrid and Advanced Propulsion Systems

10 Hours

Hybrid Vehicle Technologies: Overview of hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and their drivetrain configurations. Advanced Propulsion Technologies: Fuel cell vehicles (FCVs), solar-powered vehicles, and alternative fuels. Thermal Management in EVs and HEVs: Heat generation and cooling requirements, strategies for managing thermal loads in electric and hybrid vehicles.

UNIT – IV: Advanced Driver-Assistance Systems (ADAS)

07 Hours

Fundamentals of ADAS: Introduction to ADAS and its role in improving safety and driving comfort. Key ADAS Technologies: Sensors and actuators used in ADAS such as cameras, radar, LIDAR, ultrasonic sensors, and their integration into vehicle systems. ADAS Features: Detailed study of features such as adaptive cruise control, lane keeping assist, automatic parking, and collision avoidance systems.

UNIT – V: Design and Safety Considerations

08 Hours

Vehicle Design for Safety: Design principles for occupant safety, pedestrian safety, and crashworthiness. Regulatory and Testing Standards: Overview of global safety standards, emissions regulations for EVs and HEVs, and testing protocols. Future Trends and Innovations: Autonomous vehicles, vehicle connectivity (V2X), and emerging trends in vehicle design and safety.

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Analyze and evaluate the mechanical and dynamic aspects of automobile systems, applying principles of vehicle dynamics and automotive safety.	L3												
2	Design and assess electric vehicle systems, including battery management and electric propulsion, to optimize performance and efficiency.	L3												
3	Implement hybrid and alternative propulsion technologies in vehicle design, considering environmental and efficiency metrics.	L3												
4	Integrate advanced driver-assistance systems into automotive designs, enhancing vehicle safety and driving experience through technological innovations.	L4												
5	Navigate the regulatory landscape for automobile design and safety, applying standards and protocols to ensure compliance and innovation in vehicle development.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3

C04	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbooks:

1. Ehsani, M., Gao, Y., Longo, S., & Ebrahimi, K. (2018). Modern Electric, Hybrid Electric, and Fuel Cell Vehicles (3rd ed.). CRC Press.
2. Erjavec, J., & Thompson, R. (2014). Automotive Technology: A Systems Approach (6th ed.). Cengage Learning.

Reference Books:

1. Denton, T. (2016). Advanced Automotive Fault Diagnosis: Automotive Technology: Vehicle Maintenance and Repair (4th ed.). Routledge.
2. Husain, I. (2011). Electric and Hybrid Vehicles: Design Fundamentals (2nd ed.). CRC Press.

TOTAL QUALITY MANAGEMENT AND RELIABILITY [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: - Understand the evolution and importance of quality control and learn the fundamental principles of Total Quality Management (TQM). - Master the application of quality improvement tools such as Kaizen, Six Sigma, and quality circles to enhance organizational processes. - Gain proficiency in establishing and maintaining Quality Management Systems, including familiarity with ISO 9000 and ISO 14000 standards. - Develop skills in assessing and improving product reliability through quantitative measures and reliability engineering techniques. - Learn to perform risk assessments and design for reliability, incorporating redundancy and robustness into product designs.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. - Show Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, ask at least three Higher order Thinking questions in the class. - Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it. - Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every concept can be applied to the real world - and when that's possible, it helps improv the students' understanding.	
UNIT – I Quality Control	09 Hours
Quality Control Management of product quality, evolution of quality control, changing quality concepts, modern concept of total quality management, contribution of quality masters (Deming, Juran, Crosby, Ishikawa, Taguchi), process control charts; statistical quality control tools; statistical process control and process capability. (CHAPTER -1)	

UNIT – II: Total Quality Management	09 Hours
Total quality management , concept of total quality, total quality maintenance, total quality in service sector; role of customer and people in total quality management; steps for quality improvement, Kaizen; organizing for effective quality management; creating quality by design assessment of customer's needs; formulation of design specifications; standardization; costs of quality; quality circles; 5-S concept; zero defect program; Six- Sigma approach.(CHAPTER-2,3)	
UNIT – III: Quality Management Systems	08 Hours
Quality Management Systems: ISO 9000 series of standard; ISO 14000 series of standards, Strategic tools and techniques for TQM, need for tools and techniques in TQM; commonly used tools for TQM; approaches and deployment of tools for quality planning – quality function deployment (QFD), concurrent engineering; tools for continuous improvement -Deming's Plan – Do – Check – Act (PDCA) cycle, Poka – Yoke (Mistake – Proofing), Taguchi's quality loss function.(CHAPTER 4)	
UNIT – IV: Reliability	06 Hours
Reliability , concept and definition, reliability parameters: Reliability as a function of time, failure rate as a function of time, constant failure rate, mean time to failure (MTTF), MTTF as a function of failure rate, mean time between failure (MTBF), mean down time (MDT), maintainability & availability, increasing failure rate, bath-tub curve; Weibull distribution, System reliability models: series system, parallel system, series-parallel system, six sigma approach in reliability.(CHAPTER 1)	
UNIT – V: Risk Assessment & Reliability in Design	07 Hours
Risk assessment & reliability design , causes of failures, failure modes & effects analysis (FMEA), faulty tree analysis (FTA); Tribological failure and monitoring techniques; Design based on reliability, redundancy in design.(CHAPTER 2,3)	

Course Outcome	Description	Bloom's Taxonomy Level												
At the end of the course the student will be able to:														
1	Implement and manage quality control systems, utilizing concepts from TQM and contributions of quality masters to enhance product and service quality.	L1												
2	Apply Six Sigma methodologies and other quality tools to systematically improve processes and reduce defects in manufacturing and service sectors.	L2												
3	Integrate ISO standards and strategic TQM tools like QFD and Poka-Yoke to ensure consistent quality and meet customer satisfaction.	L3												
4	Analyze and improve system reliability using statistical methods, reliability modeling, and Weibull distribution to predict and enhance product lifespan.	L2												
5	Conduct comprehensive risk assessments and reliability analysis in design, employing techniques like FMEA and FTA to anticipate and mitigate potential failures.	L3												
Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3

C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbook:

1. Lal, H. (2015). Total Quality Management – A Practical Approach. New Age International (P) Ltd. Publishers.
2. Mondal, S. K. (2009). Total Quality Management Principles and Practice. Vikas Publishing House Pvt. Ltd.

Reference Books:

1. Feigenbaum, A. V. (1991). Total Quality Control. McGraw-Hill Book Company.
2. Juran. (1988). Quality Control Handbook. McGraw-Hill Book Company.

E-Resources:

https://kanchiuniv.ac.in/coursematerials/ECE_COURSE_MATERIAL_ODD%20SEMESTER/ECE_COURSE%20MATERIAL_ODD%20SEMESTER/Mrs.V.UMA_TOTAL%20QUALITY%20MANAGEMENT.pdf

RENEWABLE ENERGY RESOURCES [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Understand the fundamental principles and social implications of renewable energy, and analyze its availability and applications worldwide and specifically in India. 2. Acquire knowledge of solar energy technologies, including the mechanics of solar radiation, thermal collectors, and photovoltaic systems. 3. Explore wind energy fundamentals, including wind characteristics, energy capture, and efficiency calculations for wind turbine installations. 4. Learn the processes involved in biomass energy production, including different biomass fuels, conversion techniques, and biogas generation. 5. Study the principles and applications of tidal and ocean thermal energy, and investigate new energy sources like hydrogen for sustainable development.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : Introduction	06 Hours
Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave	

energy, ocean thermal energy, biomass energy, geothermal energy, oil shale. Introduction to Internet of energy (IOE). <i>(Text Book-1: Chapter 1: 1.1 to 1.2)</i>	
UNIT – II: Solar Energy	10 Hours
Solar Energy- Solar radiation its measurements and prediction - solar thermal collectors - flat plate collectors, concentrating collectors – applications - heating, cooling, desalination, drying, cooking, etc. Principle of photovoltaic conversion of solar energy - types of solar cells and fabrication -photovoltaic applications - battery charging, domestic lighting, street lighting. <i>(Text Book-1: Chapter 2.1: 2.12).</i>	
UNIT – III: Wind Energy	08 Hours
Wind Energy- Wind energy - energy chains - application - historical background, merits and limitations - nature of wind - planetary and local day / night winds - wind energy quantum - power in wind- turbine efficiency - torque thrust calculations - velocity at different heights - site selection - components of wind energy conversion system (WECS). <i>(Text Book-1: Chapter 6: 6.1 to 6.16)</i>	
UNIT – IV: Energy from Biomass	06 Hours
Energy from biomass - biomass as renewable energy source - types of bio mass fuels - solid, liquid and gas - biomass conversion techniques- wet process, dry process photosynthesis-biogas generation - factors affecting bio- digestion - classification of bio gas plant - continuous, batch and fixed dome types - advantages and disadvantages . <i>(Text Book-1: (Chapter 07: 7.1 to 7.13)</i>	
UNIT – V: Tidal, Ocean Thermal Energy and New Energy Sources	09 Hours
Tidal Energy: tide – spring tide, neap tide – tidal range – tidal power – types of tidal power plant – single and dual basin schemes – requirements in tidal power plant - ocean thermal energy conversion (OTEC): principle - open and closed OTEC cycles. Hydrogen as a renewable energy source - sources of hydrogen - fuel for vehicles - hydrogen production.fuel cell – principle of working, construction and applications <i>(Text Book-1: Chapter 8,9 &11): 8.1 to 8.06,9. to 9.10 & 11.1 to 11.8)</i>	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Evaluate the global and local implications of renewable energy sources and apply sustainable practices and technologies in energy projects.	L1
2	Design and optimize solar energy systems for a variety of applications, including heating, cooling, and power generation, using knowledge of solar radiation and photovoltaic technologies.	L2
3	Analyze and implement wind energy solutions by understanding wind dynamics, assessing site potential, and calculating energy yields and system efficiencies.	L3
4	Develop and manage biomass energy projects by applying various conversion techniques and understanding the operational parameters of different types of biogas plants.	L2
5	Design and assess tidal and ocean thermal energy systems, and integrate emerging technologies such as hydrogen fuel cells into renewable energy solutions.	L3
Table: Mapping Levels of COs to POs / PSOs		

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)				2: Moderate (Medium)						1: Poor (Low)				

Textbooks:

1. Rai, G. D. (2010). Non-conventional Resources of Energy (4th ed.). Khanna Publishers.
2. Khan, B. H. (2009). Non-Conventional Energy Resources (2nd ed.). McGraw Hill.

Reference Books:

3. Rao, S., & Parulekar, B. B. (2005). Energy Technology (4th ed.). Khanna Publishers.
4. Mackay, D. J. C. (2009). Sustainable Energy – Without the Hot Air. UIT Cambridge.
(Note: Corrected publisher information for accuracy)

E-Resources:

1. <https://www.renewableenergyworld.com/>
2. <https://www.renewableenergyhub.co.uk/>
3. <https://www.edfenergy.com/energywise/renewable-energy-sources>
4. <https://www.energy.gov/eere/renewable-energy>

RAPID MANUFACTURING TECHNOLOGIES [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand the historical development and fundamental principles of rapid prototyping technologies and their impact on modern manufacturing and design. 2. Gain proficiency in operating and applying various liquid-based, solid-based, and powder-based rapid prototyping systems. 3. Learn the technical aspects and applications of advanced rapid prototyping processes such as Stereolithography, Fused Deposition Modeling, and Selective Laser Sintering. 4. Explore the range of materials available for rapid prototyping, including polymers, metals, ceramics, and composites, and their specific applications in prototyping and manufacturing. 5. Acquire skills in reverse engineering methodologies, from data acquisition through contact and non-contact devices to the creation of CAD models and functional prototypes.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I : INTRODUCTION	06 Hours

History – Development of RP systems – Applications in Product Development, Reverse Engineering, Rapid Tooling, Rapid Manufacturing- Principle –Fundamental – File format – Other translators – medical applications of RP – On demand manufacturing – Direct material deposition - Shape Deposition Manufacturing.

UNIT – II: LIQUID BASED RAPID PROTOTYPING SYSTEMS

10 Hours

Classification – Liquid based system - Stereolithography Apparatus (SLA), details of SL process, products, Advantages, Limitations, Applications and Uses. Solid based system – Fused Deposition Modeling, principle, process, products, advantages, applications and uses - Laminated Object Manufacturing

UNIT – III: POWDER BASED RAPID PROTOTYPING SYSTEMS

08 Hours

Selective Laser Sintering – principles of SLS process, principle of sinter bonding process, Laser sintering materials, products, advantages, limitations, applications and uses. Three-Dimensional Printing – process, major applications, research and development. Direct shell production casting – key strengths, process, applications and uses, case studies, research and development. Laser Sintering System, e-manufacturing using Laser sintering, customized plastic parts, customized metal parts, e-manufacturing - Laser Engineered Net Shaping (LENS).

UNIT – IV: MATERIALS FOR RAPID PROTOTYPING SYSTEMS

06 Hours

Nature of material – type of material – polymers, metals, ceramics and composites liquid based materials, photo polymer development – solid based materials, powder-based materials – case study.

UNIT – V: REVERSE ENGINEERING AND NEW TECHNOLOGIES

09 Hours

Introduction, measuring device- contact type and non-contact type, CAD model creation from point clouds-preprocessing, point clouds to surface model creation, medical data processing - types of medical imaging, software for making medical models, medical materials, other applications - Case study.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Evaluate and select the most appropriate rapid prototyping technologies for specific applications in product development and manufacturing.	L1
2	Optimize the use of liquid-based and solid-based rapid prototyping systems to enhance product design and reduce development time.	L2
3	Integrate powder-based rapid prototyping methods, such as Selective Laser Sintering and 3D Printing, effectively in the creation of functional prototypes and end-use parts.	L3
4	Synthesize knowledge of various materials used in rapid prototyping to choose the best options based on the mechanical properties and application requirements.	L2
5	Implement advanced reverse engineering techniques to reconstruct accurate digital models from physical objects, particularly for customized medical applications.	L3
Table: Mapping Levels of COs to POs / PSOs		
COs	Program Outcomes (POs)	PSOs

	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbooks:

1. Noorani, R. I. (2005). Rapid Prototyping: Principles and Applications (1st ed.). Wiley & Sons.
2. Chua, C. K., Leong, K. F., & Lim, C. S. (2003). Rapid Prototyping: Principles and Applications (2nd ed.). World Scientific Publishing Co. Pvt. Ltd.

Reference Books:

1. Pham, D. T., & Dimov, S. S. (2001). Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling (1st ed.). Springer-Verlag London Limited.
2. Liou, F. F. (2007). Rapid Prototyping and Engineering Applications (2nd ed.). CRC Press.

PROFESSIONAL ELECTIVE IV

Industrial Automation and Control [As per Choice Based Credit System (CBCS) scheme] SEMESTER – V			
Subject Code	:	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L–T–P–S	: 3–0–0–0		
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Examine the architecture and components of advanced industrial automation systems, emphasizing the integration and scalability of these systems within modern industries. 2. Understand and apply advanced control strategies such as Model Predictive Control, Fuzzy Logic, and Adaptive Control to optimize industrial processes. 3. Analyze the role and implementation of various industrial communication protocols and network designs, focusing on their impact on system performance and security. 4. Assess and implement safety and regulatory standards pertinent to industrial automation, with a focus on risk management and compliance. 5. Explore emerging technologies and trends in industrial automation, evaluating their potential to enhance efficiency, sustainability, and innovation in manufacturing processes.			
<u>Teaching-Learning Process (General Instructions)</u> These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Overview of Industrial Automation Systems			09 Hours
Automation Concepts and Components: Review of basic concepts in automation, emphasizing components not covered in basic courses, such as advanced sensors, actuators, and final control elements. System Architecture: Hierarchical structure of industrial automation systems including enterprise level, control level, and field level. Integration Challenges: Discussion on the integration of			

various automation components and systems within an existing industrial setup.	
UNIT – II: Advanced Control Strategies in Automation	09 Hours
Advanced Control Techniques: Beyond PID—Model Predictive Control (MPC), Fuzzy Logic Control, and Adaptive Control applications in industrial settings. Real-Time Control Systems: Exploration of real-time operating systems (RTOS) in industrial automation and the implications for system design and reliability. Data-Driven Control: Introduction to the role of big data and machine learning in predictive maintenance and process optimization.	
UNIT – III: Communication Technologies in Industrial Automation	06 Hours
Industrial Communication Protocols: Detailed examination of protocols like EtherCAT, Modbus, PROFIBUS, and PROFINET, and their applications in industrial automation. Network Design and Security: Designing robust industrial networks and addressing cybersecurity challenges in industrial control systems. Wireless and Mobile Communications: The use of wireless sensor networks and mobile devices in monitoring and controlling industrial processes	
UNIT – IV: Safety and Regulatory Standards	07 Hours
Safety Standards: In-depth look at international safety standards such as ISO 13849 and IEC 62061, and how they influence the design and operation of automation systems. Regulatory Compliance: Understanding the impact of regulations on industrial automation, focusing on environmental, safety, and quality control standards. Hazard Analysis and Risk Assessment: Techniques and methodologies for assessing risks and implementing safety measures in automated environments.	
UNIT – V: Case Studies and Emerging Trends	08 Hours
Innovative Applications: Exploration of cutting-edge applications in industrial automation such as collaborative robots, augmented reality in maintenance, and AI-driven process control. Sustainability and Energy Efficiency: Discussion on the role of automation in enhancing energy efficiency and sustainability in manufacturing processes. Future of Industrial Automation: A look at ongoing research, potential future technologies, and their expected impact on the field of industrial automation.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Design and evaluate the architecture of advanced industrial automation systems, demonstrating an ability to integrate various automation components effectively.	L2 & L3
2	Implement and critique advanced control strategies in simulated industrial scenarios, showcasing enhanced process efficiency and adaptability.	L2 & L3
3	Develop robust communication networks for industrial automation, applying knowledge of protocols and security measures to ensure reliable and secure operations.	L3

4	Apply international safety and regulatory standards to automation projects, ensuring compliance and prioritizing workplace safety and environmental sustainability.	L4
5	Assess and incorporate emerging technologies into industrial automation systems, demonstrating foresight and innovation in tackling future challenges in automation.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Krutz, R. L. (2016). Industrial Automation and Control System Security Principles (2nd ed.). ISA.
2. Love, J. (2007). Process Automation Handbook: A Guide to Theory and Practice. Springer.

Reference Books:

1. Lipták, B. G. (2005). Instrument Engineers' Handbook: Process Control and Optimization (4th ed.). CRC Press.
2. Groover, M. P. (2014). Automation, Production Systems, and Computer-Integrated Manufacturing (4th ed.). Pearson.

COMPUTATIONAL TOOLS FOR THE ADDITIVE MANUFACTURING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:		Credits	:	03
Hours / Week	:	03 Hours	Total Hours	:	39 Hours
L-T-P-S	:	3-0-0-0			

Course Learning Objectives:

This Course will enable students to:

1. Provide students with a comprehensive understanding of the various types of additive manufacturing processes and their applications in industry.
2. Equip students with practical skills in using CAD software for designing and optimizing 3D models specifically for additive manufacturing.
3. Teach students how to perform finite element analysis (FEA) and computational fluid dynamics (CFD) simulations to assess and improve the structural and thermal performance of AM parts.
4. Enable students to develop and optimize process plans, including layer slicing, path planning, and toolpath generation, for efficient additive manufacturing operations.
5. Familiarize students with emerging technologies and innovations in additive manufacturing, including multi-material printing and the integration of AI and machine learning, and to critically assess their potential applications.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

- **Lecture method** means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes.
- **Interactive Teaching: Adopt the Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show **Video/animation** films to explain functioning of various concepts.
- Encourage **Collaborative** (Group Learning) Learning in the class.
- To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
- Adopt **Problem Based Learning**, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
- Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
- Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the students' understanding.

UNIT – I : Introduction	09 Hours
Overview of Additive Manufacturing (AM), Types of AM processes (SLA, SLS, FDM, etc.), Applications of AM in various industries, Introduction to Computational Tools for AM, Overview of key software and tools (CAD, CAM, CAE, etc.), Basics of 3D modeling and design for AM	

UNIT – II: CAD and Design for Additive Manufacturing	09 Hours
Computer-Aided Design (CAD) Basics, Introduction to CAD software (SolidWorks, AutoCAD, Fusion 360, etc.), Creating and manipulating 3D models, Design considerations specific to AM, Advanced CAD Techniques for AM, Topology optimization, Generative design, Case studies of optimized designs for AM	
UNIT – III: Simulation and Analysis for Additive Manufacturing	06 Hours
Finite Element Analysis (FEA) for AM, Basics of FEA and its importance in AM, Software tools for FEA (ANSYS, Abaqus, etc.), Stress, strain, and thermal analysis of AM parts, Computational Fluid Dynamics (CFD) in AM, Basics of CFD and its applications in AM, Simulation of material flow in AM processes, Software tools for CFD (Fluent, COMSOL, etc.)	
UNIT – IV: Process Planning and Optimization	07 Hours
Process Planning for AM, Layer slicing and path planning, Toolpath generation, Software tools for process planning (Materialise Magics, Simplify3D, etc.), Process Parameter Optimization, Key process parameters in AM, Impact of parameters on part quality, Optimization techniques and software tools	
UNIT – V: Case Studies and Emerging Technologies	08 Hours
Case Studies in Additive Manufacturing, Industrial applications and success stories, Challenges and solutions in AM projects, Guest lectures from industry experts, Emerging Technologies in AM, Multi-material and hybrid AM, Integration of AI and machine learning in AM, Future trends and innovations in AM	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply CAD software to create and manipulate 3D models tailored for additive manufacturing processes.	L2 & L3
2	Analyze the structural and thermal performance of AM parts using finite element analysis (FEA) and computational fluid dynamics (CFD) simulations.	L2 & L3
3	Optimize process parameters to enhance the quality and efficiency of additive manufacturing operations.	L3
4	Develop comprehensive process plans including layer slicing, path planning, and toolpath generation for different AM technologies.	L4
5	Evaluate and integrate emerging technologies in additive manufacturing, such as multi-material printing and the use of AI and machine learning in AM processes.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3

CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Textbooks:

1. Gibson, I., Rosen, D., & Stucker, B. (2015). Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing. Springer.
2. Leary, M. (2019). Design for Additive Manufacturing: Developments in Plastic and Metal Printing. Elsevier.

Reference Books:

1. Zhou, K., & Yang, S. (2018). Additive Manufacturing: Materials, Processes, Quantifications and Applications. CRC Press.
2. Shah, J. J., Mäntylä, M., & Nau, D. S. (1995). Computational Methods for Design and Manufacturing. Prentice Hall

FUNDAMENTAL OF DRIVES AND DC MACHINE MODELING [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER- VII			
Subject Code	:	Credits	: 03
Hours/Week	: 03 Hours	Total Hours	: 39Hours
L-T-P-S	: 3-0-0-0		
Course Learning Objectives: This course will enable students to: 1. understand the fundamental concepts of electric drives 2. provide knowledge of power converters and inverters 3. analyze the mathematical modeling, drives of SRM and induction motors 4. introduce permanent magnet motor characteristics, drives 5. provide knowledge of various charging technologies			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method but different <i>types of teaching methods</i> that may be adopted to develop the course outcomes. • Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. • Show Video/animation films to explain the functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher-order Thinking questions in the class. • Adopt Problem-Based Learning, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding. • Practical experimentation of material testing of different metals and alloys			
Unit-1			8 Hours
Electric Drives Concept of electric drives - Classifications - Types of loads - Four-quadrant drive - Dependence of loadtorque on various factors - Dynamics of motor-load combination - Steady state stability of an electric drive system - Load Equalization - Control and Analysis of DC drives fed through single-phase and three-phase semi-converter - full-converter - phase-controlled configuration - Vector control - Energy efficient drives -			

losses in electrical drive systems	
Unit-2	7 Hours
Power Converters for EV: Introduction – Performance parameters of DC-DC conversion – Step-up and step-down converters with RL load – Switching mode regulators – Buck converter – Boost converter – Buck-Boost converter – Cuk converter – Limitations of single stage conversion – Comparison of converters – Inverter's introduction – Performance parameters – Principle of operation – Three phase inverters – Voltage control of three phase inverter – Current source inverter.	
Unit-3	7 Hours
Induction Motor Drives: Poly-phase Induction Motor- Characteristics, equivalent circuit, phasor diagram, dq-modelling; Scalar control-based induction motor drive; Vector control-based induction motor drive SRM Motor Drives Characteristics - Power converters - Control methods - Rotor position sensing - Closed loop control - Sensor-less operation	
Unit-4	9 Hours
Permanent Magnet Motor Drives PMSM introduction - Working principle - Magnetic circuit analysis - Torque and emf equations - Power converter - Closed loop control – PMSM introduction – Working principle - Torque equation - Phasor diagram – dq modelling - Vector control based PMSM drive Generation and Transmission of Electrical Energy Introduction – Types of generating stations - Controlling the power balance between generator and load – Hydropower generation stations – Thermal generating stations - Components of power distribution system – Tower grounding – Equivalent circuit of a line - Evolution of Electric Grid - Smart Grid Concept - Difference between conventional and Smart Grid - Phasor Measurement Unit	
Unit-5	8 Hours
EV Charging Technology: EV charging technology - Types of charging systems - Schematic comparison between AC Charger and DC Fast charger - Charging standards - Fundamental principle of wireless charging - Wireless charging technologies - Comparison between Conductive and Inductive charging schemes of EV – Wireless charging methods for EVs. Contemporary issues: Guest lectures from Industries, Research and Development Organisations	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the principles of electric drives to analyze and control various types of loads and drive systems, including four-	L2 & L3

	quadrant drives and energy-efficient drives.	
2	Implement and evaluate different DC-DC converters and inverters, including buck, boost, buck-boost, and three-phase inverters, to optimize performance parameters for electric vehicle applications.	L2 & L3
3	Analyze and design control strategies for poly-phase induction motor drives and switched reluctance motor (SRM) drives, including both scalar and vector control methods.	L3
4	Develop and implement control methods for permanent magnet motor drives, including PMLDC and PMSM, utilizing magnetic circuit analysis, torque equations, and dq modeling.	L4
5	Evaluate and compare various EV charging technologies, including AC and DC charging systems, wireless charging technologies, and different charging standards, to enhance the efficiency and effectiveness of EV charging infrastructure	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PS Os	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Wildi, T. (2014). Electrical Machines, Drives, and Power Systems (6th ed.). Pearson India.
2. Mohan, N. (2011). Power Electronics: A First Course. John Wiley & Sons Inc.

Reference Books:

1. Krishnan, R. (2017). Permanent Magnet Synchronous and Brushless DC Motor Drives. CRC Press.
2. Muhammad, R. H., Narendra, K., & Ashish, R. K. (2014). Power Electronics Devices, Circuits and Applications. Pearson Education.

ENERGY MANAGEMENT AND ECONOMICS [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
<u>Course Learning Objectives:</u> This Course will enable students to: 1. Understand the types and characteristics of various energy resources and systems 2. Explore strategies for managing energy demand and the principles behind energy pricing and market structures 3. Understand the principles and technologies used to enhance energy efficiency in various applications 4. Gain knowledge about various renewable energy technologies and their operational principles. Examine the policies and regulations that support the development and integration of renewable energy 5. Master advanced methods for the economic evaluation of energy projects, including lifecycle costing and risk analysis	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	06 Hours
INTRODUCTION TO ENERGY MANAGEMENT AND ECONOMICS: Overview of energy systems and types of energy resources, Fundamentals of energy management, Basic economic principles relevant to energy, The role of energy in the global economy, Energy policies and regulations.	
UNIT – II	08 Hours

ENERGY SUPPLY AND DEMAND MANAGEMENT:

Energy supply chain and infrastructure, Factors influencing energy demand, Demand-side management and load forecasting, Energy pricing and market structures, Economic analysis of energy supply and demand.

UNIT - III

09 Hours

ENERGY EFFICIENCY AND CONSERVATION:

Principles of energy efficiency, Technologies and practices for improving energy efficiency. Economic analysis of energy efficiency projects, Barriers and incentives for energy conservation, Case studies on successful energy efficiency programs

UNIT - IV

07 Hours

RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT:

Overview of renewable energy sources, Integration of renewable energy into the grid. Economic viability of renewable energy projects, Policy and regulatory frameworks for renewable energy, Environmental impacts and sustainability considerations.

UNIT - V

06 Hours

ECONOMIC ANALYSIS AND POLICY IN ENERGY:

Economic evaluation of energy projects (Cost-Benefit Analysis, Net Present Value, Internal Rate of Return), Energy policy analysis and its economic impacts, Energy market dynamics and investment strategies, Risk management in energy projects, Future trends in energy economics and policy.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze different types of energy resources and their roles in energy systems and the economy and also Evaluate the effectiveness of various energy management strategies in optimizing energy use.	L2 & L3
2	Analyze the components and efficiency of energy supply chains and infrastructure. Develop effective demand-side management strategies tailored to specific energy markets and consumer needs	L2 & L3
3	Evaluate various technologies and practices for their potential to improve energy efficiency across different applications. Create strategies to overcome barriers to energy conservation and promote energy-saving practices.	L3
4	Evaluate different renewable energy technologies for their operational principles, applications, and environmental impact. Develop policy recommendations that support the adoption and integration of renewable energy technologies.	L4
5	Apply advanced methods like lifecycle costing and risk analysis to evaluate the financial viability of energy projects.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

TEXT BOOKS:

1. Frank Kreith, D. Yogi Goswami (2017), Energy Management and Conservation Handbook, CRC Press.
2. Alan P. Rossiter and Beth P. Jones (2015), Energy Management and Efficiency for the Process Industries, John Wiley & Sons

REFERENCE BOOKS:

1. Francis Vanek, Louis Albright, and Largus Angenent (2020), Energy Systems Engineering: Evaluation and Implementation, McGraw-Hill Education.
2. Charles W. Donovan (2019), Renewable Energy Finance: Powering the Future, Imperial College Press

E-Resources:

1. <https://beeindia.gov.in/en>
2. <https://mnre.gov.in/>

COMPUTATIONAL FLUID DYNAMICS (CFD) [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Provide students with a thorough understanding of the governing equations of fluid dynamics and their applications in solving real-world fluid flow problems. 2. Equip students with the knowledge and skills to derive and apply finite difference and finite volume methods for solving diffusion and convection-diffusion equations. 3. Enable students to analyze and implement various discretization schemes, ensuring properties such as conservativeness, boundedness, and transportiveness in numerical solutions. 4. Teach students advanced flow field analysis techniques, including the use of pressure correction algorithms and staggered grid methods, for accurate simulation of fluid flow. 5. Familiarize students with turbulence modeling and mesh generation techniques, and train them in using CFD software tools for complex fluid dynamics simulations.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I Introduction	06 Hours
Governing equations and boundary conditions: Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-	

averaged equations for Turbulent Flow – Turbulent-Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.

UNIT – II: Finite difference and finite volume methods for diffusion

08 Hours

: Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three –dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.

UNIT – III: Finite volume method for convection diffusion

09 Hours

Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.

UNIT – IV: Flow field analysis

07 Hours

Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

UNIT – V: Turbulence models and mesh generation

06 Hours

Turbulence models, mixing length model, Two equation (k-ε) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the governing equations of fluid dynamics, including continuity, momentum, and energy equations, to solve fluid flow problems with appropriate boundary conditions.	L2 & L3
2	Implement finite difference and finite volume methods to derive and solve diffusion problems in one, two, and three dimensions, utilizing both explicit and implicit schemes.	L2 & L3
3	Analyze convection-diffusion problems using various discretization schemes, such as central, upwind, hybrid, and QUICK schemes, to ensure properties like conservativeness and boundedness.	L3
4	Develop and apply flow field analysis techniques using finite volume methods, including the representation of pressure gradients, momentum equations, and pressure correction algorithms like SIMPLE and PISO.	L4
5	Evaluate and implement turbulence models and mesh generation techniques, including structured and unstructured grid generation, to improve the accuracy and efficiency of CFD simulations.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2

C01	3	2	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Versteeg, H. K., & Malalasekera, W. (2007). An Introduction to Computational Fluid Dynamics: The Finite Volume Method (2nd ed.). Pearson Education Ltd.
2. Ghoshdastidar, P. S. (1998). Computer Simulation of Flow and Heat Transfer. Tata McGraw Hill Publishing Company Ltd.

Reference Books:

1. Patankar, S. V. (2004). Numerical Heat Transfer and Fluid Flow. Hemisphere Publishing Corporation.
2. Chung, T. J. (2002). Computational Fluid Dynamics. Cambridge University Press.

PROFESSIONAL ELECTIVE V

Robot Manipulators [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Subject Code	:	Credits	03
Hours / Week	:	Total Hours	39 Hours
L-T-P-S	:	3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Explore advanced mechanical designs and configurations of robot manipulators to enhance functionality and performance in various applications. 2. Analyze sources of error and implement precision enhancement techniques to improve the accuracy and reliability of robot manipulators. 3. Master advanced control strategies for robot manipulators, focusing on non-linear control and force control to handle complex interaction dynamics. 4. Integrate and optimize the use of various sensors in robot manipulators to enable real-time feedback and sensor-based control in dynamic environments. 5. Investigate the application of robot manipulators in diverse industries, understanding the requirements and challenges of each sector, and examining future trends in manipulator technology.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I : Advanced Manipulator Mechanics			09 Hours
Mechanical Design of Manipulators: Study of structural aspects, materials, and design criteria for robustness and performance. Joint and Link Configurations: Analysis of different joint types (revolute,			

prismatic) and their influence on manipulator functionality. Grippers and End Effectors: Detailed examination of end effector design and functionality, including adaptive and smart grippers.	
UNIT – II: Precision and Accuracy in Robot Manipulators	09 Hours
Sources of Error: Identification of mechanical, electrical, and computational errors affecting accuracy. Error Compensation Techniques: Methods to enhance precision, including calibration and error modeling. Performance Metrics: Defining and evaluating performance metrics such as repeatability, accuracy, and resolution.	
UNIT – III: Advanced Control of Robot Manipulators	06 Hours
Non-linear Control Techniques: Strategies like feedback linearization and sliding mode control. Force Control Strategies: Including impedance and admittance control for handling interactions with environments. Redundancy Resolution: Techniques for utilizing extra degrees of freedom for optimization of control tasks.	
UNIT – IV: Integration of Sensors in Manipulators	07 Hours
Sensor Types and Placement: Discussion on the integration of tactile, force, and vision sensors into robot manipulators. Sensor-Based Control: Real-time sensor feedback integration in control schemes for enhanced adaptability. Sensor Fusion: Techniques to combine data from multiple sensors for improved decision-making and accuracy.	
UNIT – V: Applications and Emerging Technologies	08 Hours
Industry-Specific Applications: Customization of manipulators for sectors like automotive, electronics, and healthcare. Collaborative Robots (Cobots): Design and control considerations for robots working in direct interaction with humans. Innovative Technologies: Exploration of soft robotics, wearable robot arms, and other cutting-edge developments.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Design and analyze robot manipulators, incorporating joint configurations and end effector choices that meet specific industrial and research needs.	L2 & L3
2	Implement and evaluate error compensation techniques to maximize the precision and accuracy of manipulators in practical applications.	L2 & L3
3	Apply advanced control algorithms to enhance the functionality and adaptability of robot manipulators in complex operational environments.	L3
4	Integrate and optimize sensor technologies within manipulator systems to enable sophisticated, real-time control and decision-making capabilities.	L4
5	Critically assess and adapt manipulator technologies to solve specific challenges in industries such as healthcare, manufacturing, and service sectors.	L4

Table: Mapping Levels of COs to POs / PSOs

	Program Outcomes (POs)	PSOs

COs	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Paul, R. P. (1981). Robot Manipulators: Mathematics, Programming, and Control. MIT Press.
2. Craig, J. J. (2017). Introduction to Robotics: Mechanics and Control (4th ed.). Pearson.

Reference Books:

1. Mittal, R. K., & Nagrath, I. J. (2003). Robotics and Control. Tata McGraw-Hill Education.
2. Angeles, J. (2014). Fundamentals of Robotic Mechanical Systems: Theory, Methods, and Algorithms (4th ed.). Springer.

POWDER METALLURGY			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Subject Code	:	Credits	03
Hours / Week	:	Total Hours	39 Hours
L-T-P-S	:	3-0-0-0	
Course Learning Objectives:			
This Course will enable students to:			
1. Understand the principles and fundamentals of powder metallurgy as a manufacturing process. 2. Identify the different powder metallurgy techniques and their applications in various industries. 3. Gain knowledge of the properties and characteristics of powder materials used in manufacturing processes. 4. Analyze the advantages and limitations of powder metallurgy compared to conventional manufacturing methods. 5. Develop the skills necessary to design, produce, and assess powder metallurgy components.			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.			
• Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
Unit 1: Introduction to Powder Metallurgy			08Hrs
Overview of powder metallurgy and its historical development. Fundamentals of powder metallurgy processes. Powder characteristics and properties. Powder production methods.			
Unit 2: Powder Compaction and Shaping			09 Hours

Principles of powder compaction. Types of compaction presses and their operation. Tooling design for powder compaction. Post-compaction shaping techniques.	
Unit 3: Sintering and Heat Treatment	06 Hours
Fundamentals of sintering and its mechanisms. Sintering furnaces and atmosphere control. Sintering kinetics and densification. Heat treatment of powder metallurgy components.	
Unit 4: Secondary Operations in Powder Metallurgy	07Hrs
Debinding techniques for removing binders from green compacts. Post-sintering treatments (e.g., impregnation, infiltration, etc.). Finishing operations for powder metallurgy components.	
Unit 5: Powder Metallurgy Applications and Advanced Techniques	08 Hrs
Automotive applications of powder metallurgy components. Aerospace and defense industry applications. Powder metallurgy in biomedical and consumer goods. Metal injection molding (MIM) and its advantages. Powder forging and its application in producing high-strength components. Powder spraying and coating techniques.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply knowledge of powder characteristics and production methods to select appropriate powders for specific powder metallurgy processes.	L2 & L3
2	Design and implement tooling for powder compaction, optimizing press types and post-compaction shaping techniques.	L2 & L3
3	Analyze sintering mechanisms and kinetics to optimize furnace conditions and atmosphere control for enhanced densification.	L3
4	Execute secondary operations such as debinding, post-sintering treatments, and finishing techniques to improve the quality and performance of powder metallurgy components.	L4
5	Evaluate and integrate advanced powder metallurgy techniques like metal injection molding, powder forging, and powder spraying in various industrial applications.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. German, R. M. (2017). Powder Metallurgy Science (4th ed.). Metal Powder Industries Federation (MPIF).
2. Cantor, B., Campbell, F. C., & Grant, P. (2014). Powder Metallurgy: Principles and Applications (1st ed.). Cambridge University Press.

Reference Books:

1. Chang, I., Zhao, Y., & Chen, M. (Eds.). (2013). Advances in Powder Metallurgy: Properties, Processing, and Applications. Woodhead Publishing.
2. Angelo, P. C., & Subramanian, R. (2008). Powder Metallurgy: Science, Technology, and Applications. PHI Learning Pvt. Ltd.

ADVANCED ENERGY STORAGE			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER- VII			
Subject Code	:	Credits	03
Hours/Week	: 03 Hours	Total Hours	: 39Hours
L-T-P-S	: 3-0-0-0		
Course Learning Objectives:			
This course will enable students to:			
1. Understand the historical evolution and current needs of energy storage, including demand variations, supply interruptions, and sustainability issues. 2. Learn about technical energy storage methods, covering potential, kinetic, thermal, chemical, electrochemical, electrostatic, and electromagnetic storage. 3. Evaluate performance factors of energy storage systems, focusing on efficiency, durability, safety, and environmental impact. 4. Compare and apply various energy storage technologies, examining their efficiency and applications in industries such as automotive and power plants. 5. Explore hydrogen fuel cells and flow batteries, including hydrogen generation, storage, and supercapacitor properties. 6. Study hybrid energy storage systems, particularly Battery combinations, for managing peak and continuous power needs in different applications.			
Teaching-Learning Process (General Instructions)			
These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes.			
• Lecture method means it includes not only traditional lecture method but different <i>types of teaching methods</i> that may be adopted to develop the course outcomes. • Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. • Show Video/animation films to explain the functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher-order Thinking questions in the class. • Adopt Problem-Based Learning, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it.			

- Show the <i>different ways to solve</i> the same problem and encourage the students to come up with their own creative ways to solve them. - Discuss how every <i>concept can be applied to the real world</i> - and when that's possible, it helps improve the student's understanding. Practical experimentation of material testing of different metals and alloys	
Unit-1	8 Hours
Storage: Historical Perspective, Introduction and Changes: Storage Needs - Variations in Energy Demand - Variations in Energy Supply - Interruptions in Energy Supply - Transmission Congestion - Demand for Portable Energy - Demand and scale requirements - Environmental and sustainability issues.	
Unit-2	7 Hours
Technical Methods of Storage: Introduction: Energy and Energy Transformations, Potential energy (pumped hydro, compressed air, springs) - Kinetic energy (mechanical flywheels) - Thermal energy without phase change passive (adobe) and active (water) - Thermal energy with phase change (ice, molten salts, steam) - Chemical energy (hydrogen, methane, gasoline, coal, oil) - Electrochemical energy (batteries, fuel cells) - Electrostatic energy (capacitors), Electromagnetic energy (superconducting magnets) - Different Types of Energy Storage Systems	
Unit-3	7 Hours
Performance Factors of Energy Storage Systems: Energy capture rate and efficiency - Discharge rate and efficiency - Dispatch ability and load flowing characteristics, scale flexibility, durability - Cycle lifetime, mass and safety - Risks of fire, explosion, toxicity - Ease of materials, recycling and recovery - Environmental consideration and recycling, Merits and demerits of different types of Storage.	
Unit-4	9 Hours
APPLICATION CONSIDERATION: Comparing Storage Technologies - Technology options- Performance factors and metrics - Efficiency of Energy Systems - Energy Recovery - Battery Storage System: Introduction with focus on Lead Acid and Lithium - Chemistry of Battery Operation, Power storage calculations, Reversible reactions, Charging patterns, Battery Management systems, System Performance, Areas of Application of Energy Storage: Waste heat recovery, Solar energy storage, Green house heating, Power plant applications, Drying and heating for process industries, energy storage in automotive applications in hybrid and electric vehicles.	
Unit-5	8 Hours
Hydrogen Fuel Cells and Flow Batteries: Hydrogen Economy and Generation Techniques, Storage of Hydrogen, Energy generation - Super capacitors: properties, power calculations - Operation and Design methods - Hybrid	

Energy Storage: Managing peak and Continuous power needs, options - Level 1: (Hybrid Power generation) Bacitor “Battery + Capacitor” Combinations: need, operation and Merits; Level 2: (Hybrid Power Generation) Bacitor + Fuel Cell or Flow Battery operation- Applications: Storage for Hybrid Electric Vehicles, Regenerative Power, capturing methods.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze various energy storage needs and assess the impact of energy demand and supply variations on storage requirements.	L2 & L3
2	Apply technical methods to design and implement different energy storage systems, including potential, kinetic, thermal, chemical, electrochemical, electrostatic, and electromagnetic storage.	L2 & L3
3	Evaluate performance factors such as energy capture rate, discharge rate, efficiency, durability, and safety for various energy storage systems.	L3
4	Compare and select appropriate storage technologies based on performance metrics, efficiency, and application-specific requirements in areas such as waste heat recovery, solar energy storage, and automotive applications.	L4
5	Develop and integrate hydrogen fuel cells, flow batteries, and hybrid energy storage systems for managing peak and continuous power needs in applications like hybrid electric vehicles and regenerative power systems.	L4

Table: Mapping Levels of COs to POs / PSOs														
COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO2	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO3	3	3	3	-	-	1	1	1	2	2	1	1	3	3
CO4	3	3	3	-	-	2	2	2	2	2	1	1	3	3
CO5	3	2	3	-	-	1	1	1	2	2	1	1	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Textbooks:

1. Stolten, D. (2010). Hydrogen and Fuel Cells: Fundamentals, Technologies and Applications. Wiley.
2. Zhang, J., Zhang, L., Liu, H., Sun, A., & Liu, R.-S. (2012). Electrochemical Technologies for Energy Storage and Conversion. John Wiley & Sons.

Reference Books:

1. Béguin, F., & Frackowiak, E. (2013). Supercapacitors: Materials, Systems, and Applications. Wiley.
2. Doughty, D., Liaw, B. Y., Narayan, S. R., & Srinivasan, V. (2010). Batteries for Renewable Energy Storage. The Electrochemical Society.

ENERGY SYSTEMS MODELLING AND ANALYSIS [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Describe fundamental principles of energy system design. Explain heat transfer mechanisms and their significance in thermal systems 2. Develop MATLAB and Simulink models for basic energy system components 3. Assess the feasibility of integrating renewable energy sources into energy systems 4. Implement control strategies to improve the performance of thermal components 5. Present a project integrating theoretical concepts with practical applications in thermal system design.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	06 Hours
FUNDAMENTALS OF ENERGY SYSTEM DESIGN: Overview of energy system design principles, Heat transfer mechanisms: conduction, convection, and radiation, Design considerations for heat exchangers, boilers, and condensers Case studies on the application of thermal system design principles	
UNIT – II	08 Hours
MODELING AND SIMULATION OF ENERGY SYSTEMS:	

Introduction to MATLAB and Simulink for thermal system simulation, Dynamic modeling of boilers, turbines, and heat exchangers, Simulation of transient and steady-state behavior in thermal systems. Optimization techniques for thermal system performance

UNIT - III

08 Hours

INTEGRATION OF RENEWABLE ENERGY SYSTEMS:

Integration of solar thermal systems with boilers and heat exchangers , Modeling biomass combustion and its integration into thermal systems ' Economic analysis and lifecycle assessment of hybrid energy systems 'Case studies on successful integration of renewable energy with thermal systems

UNIT - IV

07 Hours

ADVANCED TOPICS IN ENERGY SYSTEM OPTIMIZATION:

Optimization algorithms for thermal energy systems , Advanced control strategies for boilers, turbines, and heat exchangers ,Emerging technologies in thermal energy, such as waste heat recovery and cogeneration , Case studies on successful application of optimization and control in thermal systems

UNIT - V

07 Hours

CASE STUDIES AND PROJECT IN ENERGY SYSTEM DESIGN:

Case Studies Analysis: Detailed analysis of successful and challenging applications of energy system design principles. Examples may include retrofitting of existing systems, integration of renewable energy, and industrial applications.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyze fundamental principles of energy system design using governing laws of heat transfer, fluid mechanics and thermodynamics	L2 & L3
2	Design intricate MATLAB and Simulink models to simulate and predict the behavior of complex thermal systems. Innovate and propose improvements based on simulation results to optimize energy system performance.	L2 & L3
3	Critique and justify the integration of diverse renewable energy sources into thermal systems and synthesize economic, environmental, and technical factors to propose sustainable hybrid energy solutions.	L3
4	Devise and execute advanced optimization algorithms to maximize energy efficiency and operational performance in thermal systems. Formulate and implement adaptive control strategies to enhance the dynamic response and stability of thermal components.	L4
5	Construct a comprehensive project integrating theoretical concepts with practical applications in energy system design. Justify project outcomes using systematic analysis and evidence-based reasoning	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
C01	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Stoecker, W. F. (1981). Design of Thermal Systems. McGraw-Hill Education.
2. Dabney, J. B., & Harman, T. L. (2015). Mastering Simulink. Pearson.

Reference Books:

1. Lund, H. (2014). Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions. Academic Press.
2. Sastry, S. S. (1988). Introductory Methods of Numerical Analysis. Prentice Hall.
3. Knopf, F. C. (2012). Modeling, Analysis, and Optimization of Process and Energy Systems. Wiley.

TOOL DESIGN	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Understand the various types of tooling materials and their industrial applications. 2. Develop capability to design and select single point and multipoint cutting tools for various machining operations. 3. Exposure to variety of locating and clamping methods available. 4. Design jigs and fixtures for simple components 5. Design/selection procedure of sheet metal and injection mold	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
UNIT – I	06 Hours
Different tooling materials: cemented carbides, coated carbides, cermet's, ceramics and polycrystalline tool materials. Selection and properties of tool materials, plastics as tool materials, Tooling materials – properties and applications of ferrous, non-ferrous and non-metallic materials. Case studies.	
UNIT – II	08 Hours
Design of single point cutting tools - various systems of specifications, geometry and their interrelation, theories of formation of chip and their effect. Design of multipoint cutting tools – Design elements, nomenclature and geometry of drill bit, milling cutter, reamer and broaching	

tool. Cutting parameters and machining time calculation for drilling, milling, reaming and broaching operation. Case studies

UNIT - III		08 Hours
Working of a power press and classification of presses. Press working terminology, Types of dies-Simple, progressive, compound and combination dies. Components of a simple die, press tool operation, die accessories, press tool operations. Shearing theory, cutting clearance between punch and die, methods of reducing cutting forces, Centre of pressure and problems, scrap strip layout. Design problems on blanking and piercing dies for simple components. Case studies		
UNIT - IV		07 Hours
Injection moulding machine and its elements, general configuration of a two plate mould. Introduction to gate, runner, parting surface, ejection system. Core and cooling system. Design problems on injection mold. Case studies		
UNIT - V		07 Hours
Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures. Location: 3-2-1 Principle of location, different types of locating elements. Clamping: Principles of clamping, types of clamping devices. Drill jigs: Different types, Types of fixtures: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centres, and modular fixtures. Case studies.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Select and evaluate different tooling materials, including cemented carbides, coated carbides, cermets, ceramics, and polycrystalline tool materials, based on their properties and applications.	L2 & L3
2	Design single and multipoint cutting tools, understanding their specifications, geometry, and the theories of chip formation, and calculate cutting parameters and machining time for various operations.	L2 & L3
3	Analyze the working and classification of power presses, and design various types of dies, including simple, progressive, compound, and combination dies, while solving design problems related to blanking and piercing dies.	L3
4	Develop and optimize injection molding processes, including the design of molds, gates, runners, parting surfaces, ejection systems, and cooling systems, with a focus on practical design problems.	L4
5	Design and implement jigs and fixtures for mass production, applying principles of location and clamping, and creating solutions for various machining operations, including turning, milling, grinding, and CNC machining.	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	1	1	1	2	2	1	1	3	3

C02	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C03	3	3	3	-	-	1	1	1	2	2	1	1	3	3
C04	3	3	3	-	-	2	2	2	2	2	1	1	3	3
C05	3	2	3	-	-	1	1	1	2	2	1	1	3	3

Textbooks:

1. Donaldson, C., LeCain, G. H., Goold, V. C., & Ghose, J. (2012). Tool Design. Tata McGraw-Hill.
2. Basu, S. K., Pal, D. K., & Mukherjee, S. C. (2009). Fundamentals of Tool Design. Oxford and IBH Publishing Co. Pvt. Ltd.

Reference Books:

1. Bhattacharyya, A. (2011). Metal Cutting and Tool Design. New Central Book Agency.
2. Jain, R. K. (2008). Production Technology. Khanna Publishers.

Major Project Phase-1 [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 1. Develop the ability to identify and formulate engineering problems. 2. Apply theoretical knowledge and practical skills to design and implement engineering solutions. 3. Foster teamwork and collaborative problem-solving abilities. 4. Enhance project management and communication skills. 5. Promote innovation and creativity in addressing real-world engineering challenges.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
Content	06 Hours
1. Identification of Problem Based on Literature Review: • Conduct a thorough literature review to identify gaps or opportunities in existing research. • Formulate a clear problem statement based on findings. 2. Finding the Supervisor: • Identify and approach faculty members with expertise in the relevant field. • Discuss the project idea and seek guidance to finalize a supervisor. 3. Finalizing Methodology/Design Phase:	

- Define the research methodology, including experimental design, simulations, or theoretical analysis.
- Develop detailed design specifications and project plan, outlining objectives, resources, and timelines.

4. Report submission and presentation

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Synthesize information from various sources to identify research gaps or opportunities.	L3
2	Formulate a precise problem statement grounded in the findings of the literature review.	L3
3	Design a comprehensive research methodology, including experimental design, simulations, or theoretical analysis, and develop detailed design specifications and a project plan outlining objectives, resources, and timelines.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3										2		3
CO2	3	3	2									2		3
CO3	3	3										1		3

Major Project Phase-2 [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VIII	
Subject Code :	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-0-0	
Course Learning Objectives: This Course will enable students to: 6. Develop the ability to identify and formulate engineering problems. 7. Apply theoretical knowledge and practical skills to design and implement engineering solutions. 8. Foster teamwork and collaborative problem-solving abilities. 9. Enhance project management and communication skills. 10. Promote innovation and creativity in addressing real-world engineering challenges.	
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.	
Content	06 ours
1. Execution: • Implement the project plan, focusing on developing prototypes, conducting experiments, and collecting data. • Apply engineering principles and problem-solving techniques to address challenges and refine designs. 2. Result Discussion: • Analyze collected data to draw meaningful insights and validate the project objectives.	

- Compare results with theoretical predictions and previous studies to assess the accuracy and reliability.

3. Conclusion:

- Summarize key findings and their implications for the field of study.
- Provide recommendations for future research or improvements based on the project's outcomes.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Execute project plans by developing prototypes, conducting experiments, and refining designs using engineering principles.	L3
2	Analyze and interpret experimental data to draw meaningful conclusions and validate project objectives.	L3
3	Summarize findings, compare with theoretical predictions, and provide recommendations for future research or improvements.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3										2		3
CO2	3	3	2									2		3
CO3	3	3										1		3

DAYANANDA SAGAR UNIVERSITY

ShavigeMalleshwara Hills, Kumaraswamy

Layout,Bengaluru - 560078, Karnataka.

SCHOOL OF ENGINEERING



**SCHEME & SYLLABUS
FOR
BACHELOR OF TECHNOLOGY (B.Tech.) – 2021
MECHANICAL ENGINEERING
(MECH)**

**(3rd to 8th SEMESTER) (WITH EFFECT
FROM 2021 - 22)**

DEPARTMENT OF MECHANICAL ENGINEERING
PROPOSED SCHEME - B.TECH – 2021 -22 ONWARDS
SEMESTER V

Sl. No.	Course Code	Course	$\frac{AU}{CR}$	Scheme of Teaching					Scheme of Evaluation		Pre-requisite
				L	T	P	S/P	C	CIA	End Exam	
1	21ME3501	Heat Transfer	CR	03	--	02	--	04	60	40	21ME2304
2	21ME3502	Dynamics of Machines and Mechanism	CR	02	--	02	--	03	60	40	--
3	21ME3503	Design of Machine Elements	CR	03			--	03	60	40	21ME2302
4	21ME3504	Digital Manufacturing	CR	03	--	--	--	03	60	40	
5	21ME35XX	Professional Elective – I	CR	03	--	--	--	03	60	40	--
6	21ME35XX	Professional Elective – II	CR	03	--	--	--	03	60	40	
7	21OEXXXX	Open Elective – I	CR	03	--	--	--	03	60	40	--
8	21ME3505	Liberal Studies	CR	02	--	--		02	60	40	--
Grand Total 800				22	--	04	--	24	480	320	

PC- Professional Core, PE-Professional Elective, OE-Open Elective, LS-Liberal Science, CR – Credit, AU – Audit, CIA – Continuous Internal ssessment

PROFESSIONAL ELECTIVE -I			
S.No	Course Code	Course Title	Group
1	21ME3506	Introduction to robotics and Automation	ROBOTICS & AUTOMATION
2	21ME3507	Additive Manufacturing Technology	ADDITIVE MANUFACTURING
3	21ME3508	Introduction to Hybrid & Electric Vehicles	HYBRID & ELECTRIC VEHICLES
4	21ME3509	Refrigeration and Air Conditioning	GENERAL
5	21ME3510	Tool Design	

PROFESSIONAL ELECTIVE -II			
S.No	Course Code	Course Title	Group
1	21ME3511	Drives & Control systems	ROBOTICS & AUTOMATION
2	21ME3512	Electrical Machines and Power Systems	
3	21ME3513	Materials for Additive Manufacturing	ADDITIVE MANUFACTURING
4	21ME3514	Automotive Chassis & Transmission Systems	HYBRID & ELECTRIC VEHICLES
6	21ME3515	Renewable Energy Sources	

DEPARTMENT OF MECHANICAL ENGINEERING
PROPOSED SCHEME – B.TECH – 2021 -22 ONWARDS

SEMESTER VI

Sl. No.	Course Code	Course	$\frac{AU}{CR}$	Scheme of Teaching					Scheme of Evaluation		Pre-requisite
				Lecture	Tutorial	Practical	Seminar/Project	No of Credits	CIA	End Exam	
1	21ME3601	Machine Design Practice	CR	02	01	02	--	04	60	40	Mechanics of solids(IV)
2	21ME3602	Finite Element Analysis	CR	03	--	02	--	04	60	40	
3	21ME3603	Control Systems Engineering	CR	03	--	02	--	04	60	40	
4	21ME36XX	Professional Elective – III	CR	03	--		--	03	60	40	
5	21ME36XX	Professional Elective – IV	CR	03	--	--	--	03	60	40	--
6	21OEXXX	Open Elective – II	CR	03	--	---	---	03	60	40	--
7	21ME3604	Liberal Studies	CR	01	--	--	--	01	60	40	--
Grand Total 800				18	01	08	--	22	420	280	

PC- Professional Core, PE- Professional Elective, OE- Open Elective, LS-Liberal Science, CR – Credit, AU – Audit, CIA – Continuous Internal Assessment

PROFESSIONAL ELECTIVE -III			
S.No	Course Code	Course Title	Group
1	21ME3605	Robot Kinematics and Dynamics	ROBOTICS & AUTOMATION
2	21ME3606	Industrial Automation-I	
3	21ME3607	Computational Tools for Additive Manufacturing	ADDITIVE MANUFACTURING
4	21ME3608	HEV / EV System Design Architecture	HYBRID & ELECTRIC VEHICLES
5	21ME3609	NVH	

PROFESSIONAL ELECTIVE -IV			
S.No	Course Code	Course Title	Group
1	21ME3610	Experimental methods for Mechanical Engineers	ROBOTICS & AUTOMATION
2	21ME3611	Experimental methods for Mechanical Engineers	ADDITIVE MANUFACTURING
3	21ME3612	Rapid Tooling and Industrial Applications	
4	21ME3613	Fundamental of Drives and DC Machine Modeling	HYBRID & ELECTRIC VEHICLES

Categories of Courses for Liberal Studies

1. Physical Education: Sports, Yoga, Marathon/Jogging, NCC, Dance
2. Psychology: Positive Psychology, Mindfulness,
3. Linguistic and communication: **Technical Communication(2)**,, Public Speaking, Group Discussions Japanese, German, **kannada (1)**, Modern Indian Languages
4. Life Skills: Aptitude, Interview skills, Research methodology
5. Management, **Economics (2)** and Entrepreneurship courses
6. Volunteering/Community activities: NSS, cYaag
7. Arts and Creativity: Creative writing, Music, Performing arts,
8. Design: **Design Thinking (1)**, Engineering Design, Ergonomics
9. Liberal STEM: **Environmental Studies (2)**
10. Humanitie, Social Studies, History, **Indian Constitution (1)**,
11. Law Cyber Crimes, Security Policies and Law, **Law for Engineers (2)**,

MINORS FOR OTHER PROGRAMS				
Sl. No	Course Name	Credit Pattern (L:T:P)	Credits	Semester
1	Engineering Materials (Theory & Practice)	2 : 0 : 2	3	3
2	Solid Mechanics (Theory & Practice)	2: 0 : 2	3	4
3	Fluids & Thermal Engineering (Theory & Practice)	3: 0 : 2	4	5
4	Digital Manufacturing (Theory & Practice)	3 : 0 : 2	4	5
5	Product Design and development (Theory & Practice) -	2: 0 : 2	3	6
6	Recent Trends in Mechanical Engineering (Robotics, Automation & Hybrid Vehicles)	3: 0 : 0	3	7
		Total	20	

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3501					
TITLE OF THE COURSE	HEAT TRANSFER					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	inlar/Projects Hours	Total Hours	Credits
	3	-	2	-	39+26	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	--	--	--

COURSE OBJECTIVES:

To understand the basic phenomenon of heat transfer and its importance in engineering applications.

To enable the students to understand the different modes of heat transfer like conduction, convection and radiation.

To understand the mechanism of heat transfer under steady and transient conditions

To illustrate the applications of convective heat transfer including heat exchangers, boiling & condensation

To understand the different laws of radiation and applying for solving engineering problems

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's taxonomy Level
C01	Compute temperature distribution and heat flow in steady-state and unsteady-state 1-D heat conduction	L3
C02	Calculate forced and free convective heat transfer coefficient and rate of heat transfer	L3
C03	Analyze performance characteristics of heat exchangers	L4
C04	Calculate radiation heat transfer between objects with simple geometries	L3
C05	Demonstrate conduction, convection, and radiation heat transfer phenomena through experiments	L2

COURSE CONTENT:	
MODULE 1	08 Hrs

Modes of heat transfer: Basic laws governing conduction, Thermal conductivity. Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, discussion on 3-D conduction in cylindrical and spherical coordinate system. One dimensional conduction equations for plane, cylinder and spheres. Overall heat transfer coefficient, Thermal conductive resistance and numerical problems. Derivation for heat flow and temperature distribution in a plane for variable thermal conductivity case, critical thickness of insulation and numerical problems.	
MODULE 2	08 Hrs
Introduction, Heat transfer through rectangular fin, infinitely long fin, short fin with insulated tip and without insulated tips. FIN efficiency and effectiveness. Numerical problems. Transient Conduction: Lumped parameter analysis, use of transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, numerical problems	
MODULE 3	08 Hrs
Natural Convection: Introduction, laminar flow, momentum and energy equations for vertical flat plate, physical significance of Grashoff number, use of correlations for free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, numerical problems. Forced Convection: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems.	
MODULE 4	07 Hrs
Fundamental concepts of radiation, different laws governing radiation heat transfer, Stefan-Boltzman law, Kirchoff's law, Planck's law, Wein's displacement law, Intensity of radiation and Lambert's cosine law, Radiation shape factor, Heat exchange by radiation between two black and diffuse gray surfaces, radiation shields, numerical problems.	
MODULE 5	08 Hrs
Heat exchangers: Classification and applications, overall heat transfer coefficient, heat exchanger analysis-Logarithmic mean temperature difference for parallel and counter flow heat exchanger, effectiveness-number of transfer units, method for parallel and counter flow heat exchanger, introduction to cross flow heat exchanger, Logarithmic mean temperature difference correction factor. Numerical problems. Condensation and Boiling: Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation. (no numerical problems).	

List of Laboratory/Practical Experiments activities to be conducted (if any) :26Hrs	
1.	Determination of thermal conductivity of metal rod.
2.	Determination of thermal conductivity of composite wall.
3.	Experiment on transient conduction heat transfer.
4.	Determination of heat transfer coefficient in natural convection.
5.	Determination of heat transfer coefficient in forced convection.

6.	Determination of temperature distribution, fin efficiency in natural / forced Convection.
7.	Determination of emissivity of a test surface.
8.	Determination of the emissive power of black body using Stefan's Boltzmann's constant.
9.	Determination of effectiveness and logarithmic mean temperature difference in parallel flow and counter flow heat exchanger.

TEXT BOOKS:

1. Incropera, F.P. and DeWitt, D.P(2011). "Fundamentals of Heat and Mass transfer , John Wiley

REFERENCES:

1. Ozisik(2002.), Heat Transfer-A Basic Approach, Tata Mc Graw Hill.
2. P K Nag (2011), Heat and Mass Transfer, Tata McGrawHill
3. J P Holaman (2009), Heat Transfer, Tata McGrawHill.
4. C.P. Kothandraman, S. Subramanyan(2014), Heat and Mass Transfer Data Book, New Age International Publishers,

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3502					
TITLE OF THE COURSE	DYNAMICS OF MACHINES AND MECHANISM					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	inlar/Projects Hours	Total Hours	Credits
	2	-	2	-	26+26	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	--	--	--

COURSE OBJECTIVES:

Understand kinematics and motion analysis in machines.
Analyze dynamic forces and moments in mechanical systems.
Model and simulate mechanical systems' dynamic behavior.
Incorporate dynamics principles into effective mechanical design.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's taxonomy Level
C01	Apply kinematic principles to analyze and describe the motion of machine components accurately.	L3
C02	Analyze and predict dynamic forces, moments, and torques in various mechanical systems.	L3
C03	Develop mathematical models to simulate the dynamic behavior of machines and mechanisms.	L4
C04	Evaluate and optimize mechanical designs to minimize vibrations and oscillations.	L3
C05	Demonstrate proficiency in utilizing simulation software for dynamic analysis and visualization.	L2
C06	Integrate dynamic considerations into the design process to create efficient and reliable mechanical systems.	L3

COURSE CONTENT:	
MODULE 1	08 Hrs
Coordinate systems, motion analysis, and velocity relationships, along with delving into advanced kinematic analysis techniques.	

MODULE 2	08 Hrs
Dynamic forces, moments, and torques in mechanical systems. Effects of inertia, friction, and external loads on system behavior.	
MODULE 3	08 Hrs
Static and dynamic balancing. Balancing of single rotating mass by balancing masses in same plane and in different planes, balancing of several rotating masses by balancing masses in same plane and in different planes.	
MODULE 4	07 Hrs
Vibrations in machines and mechanisms. Different vibration types, their implications, and their effects on system stability and performance.	
MODULE 5	08 Hrs
Gyroscopic effects, which come into play in rotating systems, and an exploration of multi-degree-of-freedom systems. Application of dynamic analysis in designing industrial machinery and robotics.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :26Hrs	
1.	Free Vibration Analysis of a Beam
2.	Forced Vibration and Resonance in Mechanical Systems
3.	Balancing Rotating Machinery
4.	Impact and Collision Analysis
5.	Dynamic Behavior of Gear Trains
6.	Centrifugal Force and Effects on Rotating Systems
7.	Dynamic Analysis of Cam-Follower Mechanisms
8.	Torsional Vibration of Shafts
9.	Whirling of Shafts and Critical Speed Analysis

Textbooks:

"Mechanisms and Dynamics of Machinery" by Hamilton H. Mabie, Charles F. Reinholtz, - John Wiley & Sons 4th edition.

"Theory of Machines and Mechanisms" by Joseph E. Shigley, John J. Uicker Jr. Oxford University Press, 4th edition

References:

"Mechanical Vibrations" by Singiresu S. Rao , Pearson 6th edition

"Dynamics of Structures" by Anil K. Chopra , Pearson 4th edition

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3503					
TITLE OF THE COURSE	Design of Machine Elements					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	III		Engineering Materials

Summary:

This course provides an in-depth exploration of machine design principles and their applications in engineering. It covers the design process, stress analysis, failure theories, dynamic loading, threaded fasteners, and keys and couplings. Through a combination of theoretical discussions and practical examples, students will gain a comprehensive understanding of machine design and its significance in various engineering disciplines.

COURSE OBJECTIVES:

The objectives of the course are:

1. Understand design process stages to analyze and solve practical engineering problems.
2. Apply stress concentration factors effectively to evaluate potential failure points in machine designs
3. Apply stress analysis techniques to design machine components effectively for static and dynamic loading conditions.
4. Analyze the behavior of threaded fasteners under various loading conditions, such as static, dynamic, and impact loads.
5. Synthesize their knowledge of keys and couplings to design efficient power transmission systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyze the significance of machine design and its impact on safety and reliability.	L2
CO2	Apply stress analysis to machine components and make informed design decisions.	L3
CO3	Design machine components for dynamic loading and estimate fatigue life.	L3
CO4	Evaluate threaded fasteners and design for static, dynamic, and impact loads.	L3
CO5	Design keys and couplings for power transmission applications	L3

COURSE CONTENT:

MODULE 1: Introduction to Machine Design	07 Hrs
Introduction to machine design and its significance in engineering. Design process and its stages. Consideration of factors like safety, reliability, and economics in machine design. Materials and Manufacturing Processes. Overview of various manufacturing processes and their impact on design. Heat treatment processes and their significance in machine component design	
MODULE 2: Stress Analysis and Failure Theories	08 Hrs
Concepts of stress and strain, principal stresses. Introduction to stress concentration factors and their influence on machine component design. Introduction to failure theories. Application of stress concentration factors and failure theories in the design of machine components.	
MODULE 3: Dynamic Loading	08 Hrs
Design for static loading and the role of stress concentration factors. RR Moore Fatigue Test. Design for fatigue loading and fatigue life estimation.	
MODULE 4: Threaded fasteners	08 Hrs
Stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints.	
MODULE 5: Keys and couplings	08 Hrs
Overview of keys and couplings in mechanical engineering. Importance of keys and couplings in power transmission. Design of flange and flexible couplings.	

Text Books:

1. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.
2. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition, 2007.

Reference Books:

1. Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.
2. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.
3. K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.
4. K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3504					
TITLE OF THE COURSE	Digital Manufacturing					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- Understand Digital Manufacturing Concepts.
- Develop Proficiency in CAD and CAM Tools.
- Integrate Digital Prototyping and Simulation.
- Implement Industry 4.0 and Automation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Apply CAD software to create and modify 3D models for manufacturing purposes.	L2
C02	Utilize CAM tools to generate toolpaths and optimize machining strategies.	L3
C03	Perform virtual testing and simulation to validate designs and manufacturing processes.	L3
C04	Identify opportunities for automation and implement Industry 4.0 principles in manufacturing settings. 1	L3
C05	Analyze the benefits and limitations of digital manufacturing methods compared to traditional approaches.	L3
C06	Develop a practical understanding of additive manufacturing techniques and their applications in various industries.	L3

COURSE CONTENT:

MODULE 1: Introduction to Digital Manufacturing	07 Hrs
Introduction to Digital Manufacturing Cover the basics of digital manufacturing, its significance in modern industry, and a comparison with traditional manufacturing methods. Explore the evolution of manufacturing technologies and the role of digital tools in optimizing production processes.	

MODULE 2: Computer-Aided Design (CAD) and 3D Modeling	08 Hrs
Focus on CAD software tools and techniques for creating detailed 3D models. Teach students how to design parts and assemblies, apply constraints, and generate engineering drawings. Emphasize parametric modeling and design for manufacturability.	
MODULE 3: Computer-Aided Manufacturing (CAM) and Toolpath Generation	08 Hrs
Introduce CAM software and its role in translating CAD designs into machine instructions. Cover toolpath generation, machining strategies, and optimizing cutting parameters. Provide practical exercises for generating efficient toolpaths for different manufacturing processes.	
MODULE 4: Digital Prototyping and Simulation	08 Hrs
Explore digital prototyping and simulation tools to validate designs and predict manufacturing outcomes. Teach students how to simulate machining operations, analyze material removal, and ensure collision-free toolpaths. Discuss the advantages of virtual testing in reducing errors and minimizing production costs.	
MODULE 5: Industry 4.0 and Automation in Manufacturing	08 Hrs
Examine the integration of digital technologies and automation in manufacturing environments. Cover topics such as the Industrial Internet of Things (IIoT), smart factories, data analytics, and robotics. Discuss real-world applications and case studies showcasing the implementation of Industry 4.0 principles.	

Text Books:

"Digital Manufacturing: Principles, Systems, and Technologies" Author: Ben Wang, Publisher: CRC Press, Edition: 1st Edition

Computer-Aided Manufacturing" Author: Tien-Chien Chang, Richard A. Wysk, Hsu-Pin Wang
Publisher: Pearson Edition: 1st Edition.

Reference Books:

1

- "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing" by Ian Gibson, David Rosen, and Brent Stucker.
- "Manufacturing Processes for Engineering Materials" by Serope Kalpakjian and Steven Schmid.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3506					
TITLE OF THE COURSE	Introduction to robotics and Automation					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Introduction to Robotics and Automation course provides a comprehensive overview of the fundamental concepts, principles, and technologies that underlie the field of robotics and automation. Through a combination of theoretical exploration and practical applications, participants will develop a solid understanding of robot anatomy, configurations, kinematics, drive systems, sensors, control mechanisms, and trajectory planning. This course aims to equip participants with the knowledge and skills needed to comprehend, design, and work with robotic systems and automation technologies in diverse industries.

COURSE OBJECTIVES:

The objectives of the course are to:

1. To introduce the basic concepts, parts and types of robots.
2. To make the student familiar with the various sensors, drive systems in robots and programming.
3. To discuss about the various applications, justification and implementation of robot.

1

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic principles of Robotic technology configurations, control and programming of Robots	L2
C02	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
C03	To choose the appropriate Sensor and Machine vision system for a given application	L3
C04	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
C05	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	08Hrs
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	08Hrs
Drive system, control system, robot drive mechanisms, hydraulic – electric – servomotor-stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	08Hrs
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	08Hrs
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS:

1. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES:

1. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004..
2. Richard D. Klafter, Robotic Engineering, Prentice Hall of India Pvt., Ltd., 2001.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3507					
TITLE OF THE COURSE	Additive Manufacturing Technology					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	23	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Additive Manufacturing Fundamentals and Applications course provides a comprehensive introduction to the world of additive manufacturing (AM), commonly known as 3D printing. This course is designed to equip participants with a deep understanding of AM processes, technologies, machine systems, pre-processing, and post-processing techniques. Through a balanced blend of theoretical knowledge and practical insights, participants will gain the necessary skills to leverage additive manufacturing in various industries such as rapid prototyping, rapid manufacturing, rapid tooling, and more.

COURSE OBJECTIVES:

The objectives of the course are to:

1. Understand the importance of additive manufacturing in advance manufacturing process.
2. Explore the potential of additive manufacturing in different industrial sectors
3. Acquire knowledge, techniques and skills to select relevant additive manufacturing process.
4. Apply 3D printing technology for additive manufacturing
5. Exploit the technology used in additive manufacturing

2

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the working principles and process parameters of additive manufacturing processes	L2
CO2	Explore different additive manufacturing processes and suggest suitable methods for building a particular component	L1
CO3	Perform suitable Pre & post processing operation based on product repair requirement	L4
CO4	Design and develop a working model using additive manufacturing Processes	L6
CO5	Able to identify, analyze and solve problems related to Additive Manufacturing	L3

COURSE CONTENT:	
MODULE 1: INTRODUCTION TO ADDITIVE MANUFACTURING	06Hrs
Introduction to AM, AM evolution, Historical development, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM.	
MODULE 2: ADDITIVE MANUFACTURING PROCESSES	09Hrs
Types, Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).	
MODULE 3: ADDITIVE MANUFACTURING MACHINES AND SYSTEMS	09Hrs
Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors. Introduction to NC/CNC/DNC machine tools, CNC programming and introduction, Hardware Interpolators, Software Interpolators, Recent developments of CNC systems for additive manufacturing.	
MODULE 4: PRE-PROCESSING IN ADDITIVE MANUFACTURING	09Hrs
Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.	
MODULE 5: POST-PROCESSING IN ADDITIVE MANUFACTURING	09Hrs
Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing, Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.	

TEXT BOOKS:

- . Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
- . Gibson, I, Rosen, D W., and Stucker,B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010

REFERENCES:

- . Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007
- . Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
- . Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3508					
TITLE OF THE COURSE	Introduction to Hybrid & Electric Vehicles:					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	39	3

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

Understand Vehicle Electrification Concepts.

Explore Powertrain Components and Integration.

Analyze Energy Management and Efficiency.

Evaluate Environmental and Economic Impacts.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply knowledge of hybrid, plug-in hybrid, and electric vehicle technologies to differentiate their operational principles and characteristics.	L2
CO2	Utilize understanding of powertrain components to analyze the integration of electric motors, batteries, and internal combustion engines in vehicle propulsion systems.	L3
CO3	Apply energy management strategies to optimize power distribution between electric and internal combustion sources, considering driving conditions and battery state of charge.	L3
CO4	Assess the environmental impact of hybrid and electric vehicles by analyzing their contribution to reduced emissions and energy consumption.	L3
CO5	Demonstrate the application of power electronics for efficient energy conversion and management in hybrid and electric vehicle systems.	L3
CO6	Formulate informed discussions on economic aspects, incentives, and market dynamics related to hybrid and electric vehicles within the context of sustainable transportation solutions.	L3

COURSE CONTENT:

MODULE 1: Basics of Electrified Vehicle Technologies	07 Hrs
Fundamental concepts of hybrid, plug-in hybrid, and electric vehicles. The comparison between conventional and electrified powertrains will be discussed, along with the historical	

development and significance of electrified vehicles.	
MODULE 2: Electric Powertrain Components and Integration	08 Hrs
includes an in-depth look at electric motors and their classifications. Battery types, characteristics, and technologies will also be explored. Additionally, we will examine the integration of electric components with internal combustion engines and the role of power electronics and inverters in electrified powertrains.	
MODULE 3: Energy Management and Efficiency Strategies	08 Hrs
Focuses on energy management algorithms used in hybrid and electric vehicles. Concepts of regenerative braking and energy recovery systems. Analyze driving conditions and battery state impact energy efficiency. Thermal management considerations for hybrid and electric systems.	
MODULE 4: Environmental and Economic Considerations	08 Hrs
Electrified vehicles in reducing emissions. The concept of life cycle assessment and environmental impact analysis will be explored. Economic factors, incentives, and the total cost of ownership for hybrid and electric vehicles. Market trends, consumer adoption, and regulatory policies.	
MODULE 5: Industry 4.0 and Automation in Manufacturing	08 Hrs
Advancements in battery technology and energy storage. Potential of electrified vehicles to contribute to smart grids and vehicle-to-grid (V2G) systems. Possibilities of hydrogen fuel cells and alternative energy sources. Integration of autonomous and connected features in electrified vehicles.	

Text Books:

Electric and Hybrid Vehicles: Design Fundamentals", Iqbal Husain, CRC Press, 2nd Edition.
Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, 2nd Edition.

Reference Books:

2

Electric Vehicle Technology Explained" by James Larminie, John Lowry
"Hybrid and Electric Vehicles: Innovations, Developments, and Technologies" by Magdi S. Mahmoud

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3509					
TITLE OF THE COURSE	REFRIGERATION AND AIR CONDITIONING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Refrigeration and Air Conditioning Systems course delves into the fundamental principles, methodologies, and applications of refrigeration and air conditioning technologies. Participants will gain a comprehensive understanding of various refrigeration methods, refrigerants, system cycles, and psychrometric processes. Through a combination of theoretical concepts and practical insights, this course equips participants with the knowledge and skills needed to design, analyze, and optimize refrigeration and air conditioning systems for diverse settings.

COURSE OBJECTIVES:

The objectives of the course are to:

1. Study the methods of refrigeration, Carnot cycle, Unit of refrigeration and coefficient of performance
2. Discuss classification and properties of refrigerants
3. Describe the Vapour compression and Vapour absorption systems
4. Understand psychrometric properties and processes
5. Study Air conditioning systems and air conditioning loads
6. Understand the measuring instruments and sensors used in air conditioning

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain different methods of refrigeration	L2
CO2	Select the suitable refrigerant based on application and environmental consideration	L3

C03	Analyse Vapour compression and Vapour absorption refrigeration systems	L4
C04	Apply the knowledge of psychrometric properties and processes for air conditioning	L3
C05	Compute air conditioning loads and Interpret airconditioning methods	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Methods of refrigeration, ice refrigeration, evaporative refrigeration, air refrigeration, vapour refrigeration, dry ice refrigeration, pulse tube refrigeration, thermo-acoustic refrigeration, reverse Carnot cycle, block diagram of refrigerator & modified reverse Carnot cycle (Bell Coleman cycle). Unit of refrigeration and coefficient of performance.	
MODULE 2	08Hrs
Refrigerants: Classification of refrigerants, desirable properties of refrigerants, environmental issues, Ozone depletion potential and global warming potential & life cycle climate performance. Selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes.	
MODULE 3	10Hrs
Vapour Compression Systems: Vapor compression cycle: p-h and T-s diagrams – deviations from theoretical cycle – sub cooling and super heating-effects of condenser and evaporator pressure on COP- multi pressure system – low temperature refrigeration – cascade systems – problems. Vapour Absorption Systems: Introduction, working of simple vapour absorption system, desirable properties of binary mixture (aqua-ammonia), Lithium-Bromide (Li- Br) absorption system, performance evaluation, applications and comparison between vapour compression system and vapour absorption system.	
MODULE 4	08Hrs
Properties of moist air-Gibbs Dalton law, specific humidity, dew point temperature, degree of saturation, relative humidity, enthalpy, humid specific heat, wet bulb temperature thermodynamic wet bulb temperature, psychrometric chart; psychrometric processes.	

MODULE 5	08Hrs
Air conditioning: Introduction, Classification, ASHRAE Nomenclature, Applications, Different Air-Conditioning Systems: Central, Unitary, Window, Packaged & Transport Air conditioning loads: Outside and inside design conditions; Sources of heat loads and calculations; Air filters; air conditioning systems with controls: temperature, pressure and humidity sensors, actuators & safety controls.	

TEXT BOOKS :

1. Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill, 2008.
2. Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 1983.

REFERENCES :

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000
2. Domkundwar, V.M (2014), Refrigeration and Air-Conditioning Data Book, Dhapapatraihill, 1998.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3510					
TITLE OF THE COURSE	TOOL DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Tool Design course offers a comprehensive exploration of tooling materials, cutting tool design, pressworking, injection molding, and jig and fixture design, all under the overarching theme of efficient and effective tool design. Through a combination of theoretical concepts and practical case studies, participants will develop a deep understanding of tooling principles, design methodologies, and their practical applications in various manufacturing processes.

COURSE OBJECTIVES:

The objectives of the course are to:

1. To understand the various types of tooling materials and their industrial applications.
2. To develop capability to design and select single point and multipoint cutting tools for various machining operations.
3. Exposure to variety of locating and clamping methods available.
4. To enable the students to design jigs and fixtures for simple components
5. To expose the students to the design/selection procedure of sheet metal and injection mold

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Select appropriate cutting tools required for producing a component.	L2
CO2	Apply design concepts of single point and multi-point cutting tools	L3
CO3	Demonstrate knowledge of various press tools and sheet tool operations.	L2
CO4	Classify and explain various types of injection moulding dies.	L4
CO5	Analyze and design a jig/fixture for a given simple component	L4

COURSE CONTENT:	
MODULE 1	08Hrs
Different tooling materials: cemented carbides, coated carbides, cermet's, ceramics and polycrystalline tool materials. Selection and properties of tool materials, plastics as tool materials, Tooling materials – properties and applications of ferrous, non-ferrous and non-metallic materials. Case studies.	
MODULE 2	08Hrs
Design of single point cutting tools - various systems of specifications, geometry and their interrelation, theories of formation of chip and their effect. Design of multipoint cutting tools – Design elements, nomenclature and geometry of drill bit, milling cutter, reamer and broaching tool. Cutting parameters and machining time calculation for drilling, milling, reaming and broaching operation. Case studies	
MODULE 3	10Hrs
Working of a power press and classification of presses. Press working terminology, Types of dies-Simple, progressive, compound and combination dies. Components of a simple die, press tool operation, die accessories, press tool operations. Shearing theory, cutting clearance between punch and die, methods of reducing cutting forces, Centre of pressure and problems, scrap strip layout. Design problems on blanking and piercing dies for simple components. Case studies	
MODULE 4	08Hrs
Injection moulding machine and its elements, general configuration of a two plate mould. Introduction to gate, runner, parting surface, ejection system. Core and cooling system. Design problems on injection mold. Case studies	
MODULE 5	08Hrs
Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures. Location: 3-2-1 Principle of location, different types of locating elements. Clamping: Principles of clamping, types of clamping devices.	
Drill jigs: Different types, Types of fixtures: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centres, and modular fixtures. Case studies.	

TEXT BOOKS :

1. Donaldson. C, Lecain.G.H and Goold.V.C, Tool Design, Tata McGraw Hill publishing company limited, New Delhi, 2002.

REFERENCES :

1. Surendra Kenav and Umesh Chandra, Production Engineering Design (Tool Design), New Delhi, 1994.
2. Mehtha.N.K, Machine Tool Design and Numerical Control, Tata Mc-Graw Hill, Third Edition, 2012.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3511					
TITLE OF THE COURSE	Drives & Control systems					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

Understand principles of drive systems.

Analyze control strategies for drive systems.

Study drive system components.

Apply knowledge to practical applications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply principles of drive systems to analyze and design various types of mechanical and electrical drive setups.	L2
CO2	Implement different control strategies to achieve desired performance characteristics in drive systems.	L3
CO3	Evaluate the impact of drive system components on overall system behavior and efficiency.	L3
CO4	Design and simulate control algorithms for closed-loop drive systems to achieve specific speed, torque, and position requirements.	L3
CO5	Troubleshoot and diagnose issues in drive and control systems, implementing corrective measures as needed.	L3
CO6	Integrate theoretical knowledge and practical skills to optimize drive systems for diverse industrial and technological applications.	L3

COURSE CONTENT:

MODULE 1: Introduction to Drive Systems and Control	07 Hrs
Provides an introduction to drive systems and their wide-ranging applications. It covers the distinctions between mechanical and electrical drive systems and introduces control strategies, including open-loop and closed-loop control approaches.	
MODULE 2: Electric Motors and Power Electronics	08 Hrs

Electric motors and their types, such as DC, AC induction, and synchronous motors. Additionally, the module delves into the role of power electronics in drive systems, explaining how motor control techniques like voltage and current control are applied.	
MODULE 3: Sensors and Feedback Devices	08 Hrs
Control algorithms, primarily focusing on Proportional-Integral-Derivative (PID) control techniques. It also covers advanced strategies like Field-Oriented Control (FOC) applied to electric motors, and introduces adaptive and predictive control techniques.	
MODULE 4: Control Algorithms and Strategies	08 Hrs
Emphasizes the integration of drive components into comprehensive systems. It discusses industrial applications where drive systems play a pivotal role and provides insights into emerging trends in drive technology.	
MODULE 5: System Integration and Applications	08 Hrs
Integration of drive components into comprehensive systems. It discusses industrial applications where drive systems play a pivotal role and provides insights into emerging trends in drive technology	

Text Books:

"Electric Drives", Ion Boldea, S.A. Nasar, CRC Press, 3rd Edition
"Control of Electric Machine Drive Systems", Seung-Ki Sul, Wiley , 1st edition.

Reference Books:

"Electric Motor Drives: Modeling, Analysis, and Control" by R. Krishnan
"Electric Drives and Electromechanical Systems: Applications and Control" by Richard Crowder, Tim Marks

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3513					
TITLE OF THE COURSE	MATERIALS FOR ADDITIVE MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Materials for Additive Manufacturing course offers a comprehensive exploration of the crucial role that materials play in the rapidly evolving field of additive manufacturing (AM). Through a combination of theoretical insights, practical case studies, and emerging trends, participants will gain a deep understanding of material selection, design considerations, mathematical modeling, and a diverse array of applications in industries ranging from biomedical to aerospace.

COURSE OBJECTIVES:

The objectives of the course are to:

1. Understand the importance of materials in additive manufacturing for various advanced process.
2. Learn the concepts and the role of materials in material design and quality aspects
3. Understand the various types of simulation and mathematical models and their practical use
4. Utilize material handling equipment in manufacturing situations
5. Have wide knowledge on usage of additive manufacturing in various applications

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Determine the appropriate materials for manufacturing process for the product to be made.	L1
C02	Analyze the suitability of a manufacturing process to convert the raw material to designed specifications.	L4
C03	Developing the material ability and expertise to apply the latest	L5

	mathematical tools and techniques for computing and engineering practice.	
C04	Perform cost analysis for various manufacturing process to minimize the cost of processing the material.	L2
C05	Application of engineering and technological knowledge to solve a wide range of rapid manufacturing problems.	L3

COURSE CONTENT:	
MODULE 1: ROLE OF MATERIALS	09Hrs
Choosing Materials for Manufacturing, Multiple Materials, Metal AM Processes & Materials Composite Materials, Biomaterials, Heirarchical Materials & Bio mimetics, Ceramics & Bio-ceramics, Shape-Memory Materials, 4D Printing & Bio-active materials, Discussion on different materials used, multifunctional and graded materials in AM	
MODULE 2: MATERIAL DESIGN & QUALITY ASPECTS	09Hrs
Machines for Additive Manufacturing, Secondary Rapid Prototyping processes, Intellectual Property, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing. Design for AM (Build orientation, Topology optimization, Conformal cooling channels).	
	3
MODULE 3: MATHEMATICAL MODELS IN AM	09Hrs
Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation. Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Model validation for different criteria). Thermal cycle, Single bead and multi bead formation in cladding based AM processes	
MODULE 4: ADDITIVE MANUFACTURING FOR BIO-MEDICAL DEVICES & OTHERS	09Hrs
Bio microfluidics, Tissue Engineering. 3D Printing in Medicine, Computer Aided Design approach, medical research and clinical grade AM materials and AM fabrication methods,	

Biomedical Applications, Direct Digital Manufacturing, Distributed Manufacturing, Mass Customization, , Aerospace & Automotive Applications, Architectural Engineering, Food & Consumer Applications, Personalized Surgery, Art, Fashion, Jewelry, Toys & Other Applications	
MODULE 5: RAPID MANUFACTURING OBJECTS	06Hrs
RM of polymeric objects, Direct and indirect routes for RM of metallic & ceramic objects, Advancement in RM (Synergistic integration of hybrid processes and multiple technologies). Smart materials.	

TEXT BOOKS:

- . Ian Gibson, David Rosen, and Brent Stucker, “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing” Springer, New York, NY, 2015.
- . Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

REFERENCES:

4. Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007
5. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
6. Duc Pham, S.S. Dimov, “Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling”, Springer-Verlag London, 2001.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3514					
TITLE OF THE COURSE	AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Automotive Chassis and Transmission Systems course provides a comprehensive study of the essential components that form the backbone of vehicles: the chassis and transmission systems. Through a blend of theoretical concepts and practical insights, participants will delve into chassis layouts, frame construction, front axle design, steering systems, clutches, gearboxes, and automatic transmission systems. This course equips participants with the knowledge and skills required to understand, analyze, and design key elements of automotive systems.

COURSE OBJECTIVES:

The objectives of the course are to:

1. To learn the types of chassis and axles.
2. To study about the steering system and its methods.
3. To understand the suspension systems and its components.
4. To learn the functions of universal joint and propeller shafts.

COURSE OUTCOMES:

3

CO No.	Outcomes	Bloom's Taxonomy Level
C01	To make students familiar with the constructional details of chassis and body.	L2
C02	The student will understand the principle and working of the Torque Converters	L2
C03	The student will know about the Automatic Transmission and Applications of Automatic Transmission	L1
C04	The student will understand the principle and working of the Hydro-Static Drive and Electric Drives.	L2
C05	The student will understand the principle and working of the clutch, gearbox	L2

COURSE CONTENT:	
MODULE 1 Chassis & Body	08Hrs
Types of chassis layout with reference to power plant locations and drive. Vehicle frames. Various types of frames. Constructional details. Materials. Testing of vehicles frames., Loads acting on vehicle frame. Integrated body construction, BIW types and corresponding design parameters, Vehicle interior system, A, B, & C Pillar.	
MODULE 2 Front Axle And Steering System	08Hrs
Types of front axle. Construction details. Materials. Front wheel geometry viz. Castor, Camber, King pin inclination, Toe-in. Conditions for true rolling motion of wheels during steering. Steering geometry. Ackerman and Davis steering system. Constructional details of steering linkages. Different types of steering gear boxes. Steering linkages and layouts. Power assisted steering.	
MODULE 3 Clutch and Gear Box	10Hrs
Clutch – function – clutch actuating mechanism – Mechanical and hydraulic types – clutch material – single plate dry clutch – dual plate dry clutch – multi plate wet clutch – semi centrifugal and centrifugal clutch – motor cycle clutch – Diaphragm clutch – fluid coupling and torque converter – Trouble shooting of Clutch. Gear Box – purpose – resistance offered to the motion of the vehicle – air resistance – rolling resistance – Resistance offered to the motion of the vehicle – gradient resistance – tractive effort -gear ratio – types of gear boxes – sliding mesh – constant mesh -synchromesh device – epicyclic – over drive – under drive and transfer cases – 4 wheel drive – gear shifting mechanism – floor shifting and steering column shifting – Automatic Gear box (CVT) -Trouble shooting of gear box.	
MODULE 4 Automatic Transmission systems	08Hrs
Principle of working of epi-cyclic gear train - Construction and working principle of Ford-T model gear box - Wilson gear box- construction, working and derivation of gear ratios - Cotal electromagnetic transmission - Automatic over-drive - Hydraulic control system for automatic transmission. Chevrolet automatic transmission - Turbo glide transmission - Power glide transmission - Toyota “ECT-i” [Automatic transmission with intelligent electronic control systems] - Mercedes Benz automatic transmission - Hydraulic clutch actuation system for automatic transmission	

MODULE 5 Hydro-Static Drive and Electric Drives	08Hrs
Hydrostatic drive – principle, types, advantages, limitations - Comparison of hydrostatic drive with hydrodynamic drive - Construction and working of typical Janny hydrostatic drive. Lay-out of elective drive - Principle of early and modified ward Leonard control systems – advantages, limitations, performance characteristics	

TEXTBOOKS:

- 1 Tim Gilles, Automotive Chassis-Brakes, Steering and Suspension, Thomson Delmer Learning, 2005.
- 2 Heldt.P.M, “Automotive Chassis”, Chilton Co., New York, June 2012.

REFERENCES:

- 1 Jornsens Reimpell, Helmut Stoll, Automotive Chassis: Engineering Principles, Elsevier, 2nd edition, 2001.
- 2 Crouse.W.H, Automotive Chassis and Body, McGraw Hill New York, 1971.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3512					
TITLE OF THE COURSE	Electrical Machines and power Systems					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

COURSE OBJECTIVES :

Identify different types of electrical machines and their components.

Interpret simple power system diagrams and schematics.

Understand the operating principles of AC and DC machines and their differences.

Design simple electrical circuits using electrical machines

Describe the challenges and benefits of renewable energy integration.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Identify and differentiate various types of electrical machines and their components.	L1
CO2	understand the fundamental principles of transformers, including electromagnetic induction and mutual inductance, and the different types of transformers used in power systems.	L1
CO3	Utilize basic load flow analysis techniques to determine power distribution and voltage profiles in power systems.	L3
CO4	Differentiate between alternating current (AC) and direct current (DC) machines in terms of their energy conversion processes.	L3
CO5	Understand the importance of integrating renewable energy sources in reducing carbon emissions and promoting sustainability.	3 L3

COURSE CONTENT:

MODULE 1		7Hrs
Fundamentals of electrical and machine systems		
Definition and significance of electrical machines and power systems. Overview of the roles of generators, motors, transformers, and other components in power systems. Basic understanding of voltage, current, power, and energy in electrical systems.		
MODULE 2		8 Hrs
Transformers: Principles and application		
Faraday's law and electromagnetic induction as the basis for transformer operation.		
Types of transformers: power transformers, distribution transformers, autotransformers, etc.		
Components and construction of transformers, including core, windings, insulation, and cooling		

systems. Transformer efficiency, voltage regulation, and power factor considerations.	
MODULE 3	8 Hrs
AC and DC Machines: Working and Characteristics DC machines: generators and motors, electromagnetic induction, commutation, and back EMF. AC machines: induction motors and synchronous machines, rotating magnetic field, torque production. Components of DC and AC machines: armature, field windings, commutator, slip rings, rotor, stator, etc. Comparisons between AC and DC machines in terms of applications and advantages.	
MODULE 4	8 Hrs
Power system analysis and stability Load flow analysis: solving power system equations to determine power flows and voltage profiles. Power system stability: transient and steady-state stability, factors affecting stability. Reactive power control and voltage regulation in power systems. Importance of power system analysis for ensuring reliability and preventing blackouts.	
MODULE 5	8 Hrs
Renewable energy integration and future trends Challenges and solutions in integrating solar, wind, and other renewable energy sources. Micro grids and smart grids: concepts and benefits for decentralized power generation. Emerging technologies: superconducting machines, energy storage systems, and advanced control strategies. Future trends in electrical machines and power systems, including sustainability and grid modernization.	

TEXT BOOKS :

- . Stephen J. Chapman (2011). "Electric Machinery Fundamentals", McGraw – Hill Publishing Company Limited, New Delhi.
- . Mohamed E. El-Hawary (2008). "Introduction to Electric Power Systems". Wiley India Private Ltd., New Delhi.

REFERENCES :

4

- . Ned Mohan (2012). "Electric Power Systems: A First Course", Wiley India Private Ltd., New Delhi.
- . John Grainger and William D. Stevenson Jr. (2011). "Power System Analysis" McGraw – Hill Publishing Company Limited, New Delhi.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3515					
TITLE OF THE COURSE	Renewable Energy Sources					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Renewable Energy Sources course provides a comprehensive exploration of various sustainable energy options that contribute to a cleaner and greener future. Through theoretical knowledge and practical applications, participants will delve into solar energy, wind energy, biomass, tidal energy, ocean thermal energy, hydropower, geothermal energy, and emerging sources like hydrogen. This course equips participants with a profound understanding of renewable energy technologies and their potential to reshape the global energy landscape

COURSE OBJECTIVES:

The objectives of the course are to:

1. To educate the students scientifically the new developments in renewable energy studies
2. To make understand the new developments in non-conventional and renewable energy studies.
3. To emphasize the significance of Green Energy Technologies

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To understand importance of solar energy applications	L1
CO2	To know the principles of power generation by wind energy	L2
CO3	To know ocean energy technologies to harness power	L2
CO4	To appreciate the use of hydrogen as renewable energy source	L3
CO5	Develop capability to do basic design of bio gas plant	L2

COURSE CONTENT:

MODULE 1 Solar Energy	10 Hrs
Solar Energy- Solar radiation its measurements and prediction - solar thermal collectors - flat plate collectors, concentrating collectors – applications - heating, cooling, desalination, drying, cooking, etc. Principle of photovoltaic conversion of solar energy - types of solar cells and fabrication -photovoltaic applications - battery charging, domestic lighting, street lighting.	
MODULE 2 Wind Energy	08 Hrs
Wind Energy- Wind energy - energy chains - application - historical background, merits and limitations - nature of wind - planetary and local day / night winds - wind energy quantum - power in wind- turbine efficiency - torque thrust calculations - velocity at different heights - site selection - components of wind energy conversion system (WECS).	
MODULE 3 Energy from Biomass	08 Hrs
Energy from biomass - biomass as renewable energy source - types of bio mass fuels - solid, liquid and gas - biomass conversion techniques- wet process, dry process photosynthesis - biogas generation - factors affecting bio- digestion - classification of bio gas plant - continuous, batch and fixed dome types - advantages and disadvantages	
MODULE 4 Tidal, Ocean Thermal Energy, Hydel and Geothermal Energy Conversion	08 Hrs
Tidal Energy: tide – spring tide, neap tide – tidal range – tidal power – types of tidal power plant – single and dual basin schemes – requirements in tidal power plant - ocean thermal energy conversion (OTEC): principle - open and closed OTEC cycles - ₄ hydel energy: micro hydro - geothermal energy: geothermal energy sources - power plant and environmental issues.	
MODULE 5 New Energy Sources	08 Hrs
Hydrogen as a renewable energy source - sources of hydrogen - fuel for vehicles - hydrogen production - direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production - storage of hydrogen - gaseous, cryogenic and metal hydride - fuel cell – principle of working, construction and applications	

TEXTBOOKS:

1. Rai.G.D, Non- conventional resources of energy, Khanna publishers, Fourth edition, 2010.
2. Khan. B.H, Non-Conventional Energy Resources, McGraw Hill, Second edition, 2009.

REFERENCES:

1. Rao.S & Parulekar, Energy Technology, Khanna publishers, Fourth edition, 2005.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3601					
TITLE OF THE COURSE	Machine Design Practice					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV		Mechanics of Solids

Summary:

This course covers mechanical power transmission systems like belt, rope, and chain drives, as well as spur, helical, bevel, and worm gears. Students will analyze stress, design for strength, and use FEA software for gear analysis. The course explores lubricants, bearing design, and practical experiments. Additionally, it focuses on clutch and brake design, considering self-locking and heat generation, with analysis using FEA software. Upon completion, students will possess the skills to optimize power transmission systems for diverse engineering applications.

COURSE OBJECTIVES:

The objectives of the course are:

- Learn Lewis equation and form factor to analyze stresses in gear teeth and design spur and helical gears for strength. Use of FEA software
- Understand the principles, advantages, and applications of belt, rope, and chain drives in various mechanical setups.
- Conduct a laboratory experiment on journal bearings to gain practical knowledge and experience.
- Design block and band brakes, considering self-locking aspects and heat generation, and analyze their behaviour using FEA software

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Design appropriate drive by analyzing load, speed, and distance parameters to optimize performance	L3
CO2	Assess the stresses in gear teeth and design for strength using the Lewis equation and form factor.	L3
CO3	Construct efficient worm gear drives by incorporating strength, dynamic, wear loads, and efficiency factors	L3
CO4	Analyze the properties of lubricants and their mechanisms in bearing systems.	L3
CO5	Evaluate the design features clutches and brakes.	L3

COURSE CONTENT:	
MODULE 1: Belt, Rope and Chain Drives	08 Hrs
Introduction to belt, rope, and chain drives: Understanding the principles, advantages, and applications of these power transmission systems in various mechanical setups. Design and selection of drives: Analyzing factors such as load, speed, and distance to determine appropriate belt, rope, and chain types for optimal performance.	
MODULE 2: Spur and Helical gears	09 Hrs
Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear load. Helical Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads. Analysis using FEA software.	
MODULE 3: Bevel and worm gears	09 Hrs
Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads. Worm Gears: Definitions, design based on strength, dynamic, wear loads and efficiency of worm gear drives. Analysis using FEA software.	
MODULE 4: Bearings	08 Hrs
Lubricants and their properties, mechanisms of lubrication bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, Heat dissipated, bearing materials, examples of journal bearing and thrust bearing design. Laboratory experiment on Journal bearing.	
MODULE 5: Clutches and Brakes	08 Hrs
4	
Design of clutches: Single plate, multi plate and cone clutches. Design of Brakes: Block and band brakes: Self-locking of brakes: Heat generation in brakes. Analysis using FEA software	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs
Static Stress analysis of gear tooth
Determination of a pressure distribution in a journal bearing.
Analysis of brake drum using FEA software

Text Books:

Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.

V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition, 2007.

Reference Books:

Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.

Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.

K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.

K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3602					
TITLE OF THE COURSE	Finite Element Analysis					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	inlar/Projects Hours	Total Hours	Credits
	3		2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1			
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COURSE OBJECTIVES :

- To help students to differentiate between finite difference and finite volume methods
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range two-dimensional real world structural and thermal problems
- To help students understand the use of higher order finite elements

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's taxonomy Level
CO1	Differentiate between finite difference and finite volume methods and their applications.	L3
CO2	Analyze a wide range two-dimensional field problems using finite element techniques	L2 4
CO3	Apply FE techniques to situations involving heat transfer by conduction	L3
CO4	Apply FE techniques in structural and solid mechanics	L3
CO5	Appreciate the use of higher order elements in FEM and apply the same	L3

COURSE CONTENT:	
MODULE 1	10Hrs

Introduction to computational methods, Finite difference method, Finite volume methods, Direct stiffness method, Integral formulation for numerical Solution – Variational method, Method of weighted residuals, Potential energy formulations; Principle of virtual work, Division of the region into elements - One dimensional linear element, Linear triangular element, Bilinear rectangular element, Representation for scalar and vector fields, Global, local and natural coordinate systems in one, two and three dimensions.	
MODULE 2	08Hrs
Governing differential equations; Integral equations for the element matrices, Triangular element matrix, Torsion of noncircular sections, General theory – Twisting of a square bar, Shear stress components, Evaluation of the twisting torque, Flow of an Ideal Fluid – Potential Formulation, Groundwater Flow, Flow Around a Cylinder, Other field problems, Derivative boundary conditions – 1D, Derivative boundary conditions – 2D,	
MODULE 3	08Hrs
Heat transfer by conduction, The one dimensional fin – 1, The one dimensional fin – 2, The composite walls, The two-dimensional fin, Boundary conditions, Long two-dimensional bodies – 1, Long two-dimensional bodies – 2, Axi-symmetric field problems, The differential equation – Axi-symmetric elements, Galerkin's method, Element matrices,	
MODULE 4	08Hrs
The axial force member - Element matrices, The truss element – Element matrices, Analysis of a pinned truss – 1, Analysis of a pinned truss – 2, A Beam element, Shape functions, Element matrices, Analysis of a statically indeterminate beam – 1, Analysis of a statically indeterminate beam – 2, A plane frame element – Element matrices, Two dimensional stress analysis - Stress, strain and Hooke's Law, The strain displacement equations, Two dimensional elasticity - Plane stress and plane strain, The displacement equations, The element matrices, Element stresses, Axi-symmetric stress analysis - Element matrices, Surface loads,	
MODULE 5	08Hrs
Iso-parametric elements in one and two dimensions, use of higher order elements, Element matrices, Introduction to Transient domain & Dynamic analysis, Changing the variables of integration- One-dimensional integrals, Two- dimensional integrals, Numerical Integration techniques- one-dimensional integrals, Quadrilateral regions, Triangular regions; Evaluating [B]; Evaluating the surface integrals, Pre and post processing, capability of commercially available FEM packages, Error analysis	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28

1.	Bars of constant cross section area, tapered cross section area and stepped bar
2.	Trusses (Minimum 2 exercises) Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc; (Minimum 6 exercises)
3.	Dynamic analysis) Fixed – fixed beam for natural frequency determination) Bar subjected to forcing function) Fixed – fixed beam subjected to forcing function
	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises)
4.	Stress analysis of a rectangular plate with a circular hole

TEXT BOOKS :

1. “Applied Finite Element Analysis”, L.J.Segerlind, John Wiley and Sons
2. “Applied Finite Element Analysis”, G.Ramamurthy, I.K.International Publishing House ,2009

REFERENCES :

1. “Concepts and Applications of Finite Element Analysis”, Cook, R. D., Malkus, D. S., Plesha, M. E., and Witt, R. J. Wiley Student Edition, Fourth Edition, First Reprint 2007.
2. “The Finite Element Method in Engineering”, Rao, S. S., Butterworth-Heinemann (An imprint of Elsevier), Published by Elsevier India Pvt. Ltd., 2007.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3603					
TITLE OF THE COURSE	CONTROL SYSTEMS ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	inlar/Projects Hours	Total Hours	Credits
	3	-	2	-	65	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- Gain a thorough understanding of the principles and theories behind control systems.
- Develop the ability to analyze control systems in both the time and frequency domains.
- Acquire skills to design and tune controllers to meet specific performance requirements.
- Master the state space analysis method for a better understanding of control system characteristics.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Apply fundamental control theory principles to model complex mechanical systems using transfer functions and state-space methods.	L3
C02	Implement time and frequency domain techniques to analyze the stability and performance of control systems.	L4
C03	Design and tune controllers, such as PID controllers and compensators, to enhance system performance and stability.	L3
C04	Apply root locus and frequency domain methods for the design and tuning of control systems.	L3
C05	Implement state space analysis to determine system controllability, observability, and stability.	L4
C06	Use computer software tools, such as MATLAB or Simulink, to simulate and analyze the behavior of control systems.	L3

COURSE CONTENT:	
MODULE 1	07Hrs
Introduction to Control Systems includes basics of control systems, differentiation between open loop and closed loop systems, system modeling using transfer functions and state space, along with block diagrams and signal flow graphs.	

MODULE 2	08Hrs
Time Domain Analysis introduces standard test signals, time response of first and second order systems, time domain specifications, steady-state errors, and stability analysis using the Routh-Hurwitz Criterion.	
MODULE 3	08Hrs
Frequency Domain Analysis consists of understanding the correlation between time and frequency response, usage of Bode and Nyquist plots, and stability analysis in the frequency domain through the Nyquist Criterion, gain and phase margins.	
MODULE 4	08Hrs
Design of Control Systems focuses on learning compensation techniques such as lead, lag, and lead-lag compensators, design of PID controllers, root locus technique, and frequency domain design with design specifications and performance indices.	
MODULE 5	08Hrs
State Space Analysis entails learning about the concept of state, state variables, state model, solutions to state equations, controllability, observability, pole placement design, and quadratic optimal control systems.	

Lab Component (26 hours):

Lab 1: Introduction to Control Systems - 4 hours

Software-based simulation to understand the basics of open and closed-loop control systems. Understanding transfer function and state-space representation of systems through modeling.

5

Lab 2: Time Domain Analysis - 5 hours

Experimental study of the response of first and second-order systems for standard test signals. Implementing Routh-Hurwitz criterion to determine system stability.

Lab 3: Frequency Domain Analysis - 5 hours

Plotting and interpreting Bode and Nyquist plots. Applying Nyquist criterion to analyze system stability.

Lab 4: Design of Control Systems - 6 hours

Designing and tuning of a PID controller for a given system. Use of root locus method for system design.

Lab 5: State Space Analysis - 6 hours

Conducting state-space analysis for control systems. Observability and controllability analysis for given systems.

Textbooks:

- Nise, N. S., "Control Systems Engineering", 8th Edition, Wiley, 2019.
- Ogata, K., "Modern Control Engineering", 5th Edition, Prentice Hall, 2009.

References:

- Dorf, R. C., and Bishop, R. H., "Modern Control Systems", 13th Edition, Pearson, 2016.
- Franklin, G. F., Powell, J. D., and Emami-Naeini, A., "Feedback Control of Dynamic Systems", 8th Edition, Pearson, 2019.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3605					
TITLE OF THE COURSE	ROBOT KINEMATICS AND DYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES :
To introduce to the control position and orientation of the tool in the three dimensional space.
To make the student familiar with the joint variables and the position and the orientation of the tool.
To discuss about creating paths for the tool to follow in order to do useful tasks
To properly regulate the system's high-speed motion.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To control both the position and orientation of the tool in the three dimensional space.	L2
CO2	The relationship between the joint variables and the position and the orientation of the tool.	L2
CO3	Planning trajectories for the tool to follow on order to perform meaningful tasks.	L3
CO4	To precisely control the high speed motion of the system.	L3 ⁵
CO5		L3

COURSE CONTENT:	
MODULE 1-INTRODUCTION	10Hrs
Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.	
MODULE 2 DIRECT KINEMATICS	08Hrs

Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.	
MODULE 3 INVERSE KINEMATICS	08Hrs
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.	
MODULE 4 WORKSPACE ANALYSIS AND TRACJECTORY PLANNING	08Hrs
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space teclnique in trajectory planning.	
MODULE 5 MANIPULATOR DYNAMICS	08Hrs
Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange Euler formulation, problems.	

TEXT BOOKS :

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Me Graw Hill Publishing company Ltd., 1995.

REFERENCES :

1. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
2. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing hguse, 1993.
3. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, MIT Press, 2003.
4. John J. Craig, Introduction to Robotics Mechanics and Control, Third Edition, Pearson, 2008.
5. Bijay K. Ghosh, Ning Xi, T.J. Tam, Control in Robtics and Automation Sensor -Based integration, Academic Press, 1999.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3606					
TITLE OF THE COURSE	INDUSTRIAL AUTOMATION-I					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to
introduce the importance of automation techniques manufacturing and process industries.

impart the role of PLC in industry automation.

expose to various control techniques employed in process automation.

develop automation system for manufacturing and process industries.

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand the concept of Industrial automation	L2
C02	Illustrate the computer based industrial automation	L3
C03	Develop automation systems for manufacturing and process industries	L4
C04	Demonstrate the use of robotics in industrial automation	5 L2

COURSE CONTENT:

MODULE 1: Introduction to Industrial Automation		09Hrs
Automation -History of Automation, Reasons for automation, Disadvantages of automation, Automation systems, Types of automation – Fixed, Programmable and Flexible automation, Automation strategies Industrial Automation Systems: Components, classification and overview of manufacturing Systems, Flexible Manufacturing Systems (FMS), Types of FMS, Applications and benefits of FMS.		
MODULE 2: Computer based industrial automation		08Hrs
Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries		

includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation.	
MODULE 3: Programmable Logic Controller	08Hrs
Controllers and Actuators: Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.	
MODULE 4: : Distributed Control System	08Hrs
Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS)	
MODULE 5: Robots Technology & Artificial Intelligence	09Hrs
Robots Technology of the future: Robot Intelligence, Advanced Sensor capabilities, Telepresence and related technologies, Mechanical design features, Mobility, locomotion and navigation, the universal hand, system integration and networking. Artificial Intelligence: Goals of AI research, AI techniques – Knowledge representation, Problem representation and problem solving, LISP programming, AI and Robotics, LISP in the factory.	

TEXT BOOKS:

1. M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5 th Edition, Pearson Education, 2009.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.

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REFERENCES:

- Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson New International, 2013.
- Lukas M.P, " Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.

N. Viswanandham, Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", 1st Edition, 2009

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3607					
TITLE OF THE COURSE	COMPUTATIONAL TOOLS FOR ADDITIVE MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	48	3

COURSE OBJECTIVES:

- The primary objective of the course is to give students both a practical and a theoretical knowledge of every stage in the additive manufacturing.
- To provide a broad overview of both hardware and software for additive manufacturing
- To introduce to methods for parametric modeling of solid objects that take into account fabrication constraints.
- To cover optimization methods that are applied to automate the design process and additive manufacturing process.
- To cover latest research work in the field of computational fabrication

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy L⁵level
CO1	Students will be able to understand and use fundamental computer graphics in the context of design and additive manufacturing	L2
CO2	Students will be able to develop geometric models both parametric and organic using computational geometry techniques	L3
CO3	Students will be able to analyze many instances of recent computational fabrication systems that seamlessly blend parametric modeling, slicing and optimization	L3
CO4	In the second part of the semester, students work in groups on large open-ended projects	L1
CO5	Students will be introduced to case studies of latest research papers in the field of additive manufacturing	L2

COURSE CONTENT:

MODULE 1	08 Hrs
Object Transformations: Object Translation, Object Scaling, Object Rotation, Object Reflection, Object Scaling module	
MODULE 2 Geometric Modeling	08 Hrs
Hermite Curve Design, Hermite Surface Design, Bezier Curve Design, Bezier Surface Design, B-Spline Curve Design, B-Spline Surface Design, Parametric Design	
MODULE 3 Computational geometry	10 Hrs
Convex Hulls: Convexity, The Incremental Algorithm, Analysis of Algorithms, Gift Wrapping and Graham Scan, Lower Bound, Divide-and-Conquer; Polygons: Diagonals and Triangulations, Tetrahedralizations, Basic Combinatorics, The Art Gallery Theorem, Scissors Congruence in 2D, Scissors Congruence in 3D; Triangulations: Point Sets, Basic Constructions, Delaunay Triangulations; Voronoi Diagram	
MODULE 4 Optimization Methods	08 Hrs
Optimization methods for preprocessing and post processing analysis of geometric models for additive process friendly part builds	
MODULE 5	08 Hrs
Case Studies from latest research papers	

TEXTBOOKS:

1. Zeid, I. (1991). CAD/CAM theory and practice. McGraw-Hill Higher Education.

REFERENCES:

5

1. Kieran, Stephen, and James Timberlake. Refabricating Architecture: How Manufacturing Methodologies are Poised to Transform Building Construction. New York, NY: McGraw-Hill, 2003. ISBN: 9780071433211.
2. Schodek, Daniel, et al. Digital Design and Manufacturing: CAD/CAM Applications in Architecture and Design. New York, NY: John Wiley & Sons, 2004. ISBN: 9780471456360.
3. Schwalbe, M., 2016. Predictive Theoretical and Computational Approaches for Additive Manufacturing: Proceedings of a Workshop.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3608					
TITLE OF THE COURSE	HEV / EV SYSTEM DESIGN ARCHITECTURE					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	0	0	-	42	3

COURSE OBJECTIVES:

The course will enable the students to:

- Explain the basics of electric and hybrid electric vehicles, their architecture
- Explain hybrid electric vehicle architecture, design and component sizing in hybrid electric vehicles.
- Analyze various electric drives suitable for hybrid electric vehicles
- Demonstrate different configurations of electric vehicles and its components.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals	L1
CO2	Analyse the use of different power electronics devices and electrical machines in hybrid electric vehicles	L3
CO3	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	5 L1
CO4	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis	L2
CO5	Understand Energy Management strategies in HEVs	L1

COURSE CONTENT:

MODULE 1 Design & Engineering – xEV	08 Hrs
xEV : micro to mild to PHEV to HEV to REEV to EV - Hybrid-Electric Vehicle Power trains - Vehicle , Energy Storage System (VESS) Design - Computational Systems Design (CSD) - Transportation Electrification	

MODULE 2 Introduction to Advanced Electric Vehicles	08 Hrs
Fundamentals of xEVs and key challenges and opportunities of AEV technologies - Engineering philosophy of various xEVs (HEV, PHEV and BEV, REEV)	
MODULE 3 Energy Storage Systems	08 Hrs
Energy storage systems used; Battery electro-chemistry, battery design and construction, charging and discharging, power density, Battery interface with motive source	
MODULE 4 Power Electronics for Electric Vehicles & Energy Conversion	08 Hrs
Power electronics including switching, AC-DC, AC-AC conversion, electronic devices and circuits used for control and distribution of electric power Electric Drives / Electromechanical Motors & motive power splitting concepts, and interface within power train system	
MODULE 5 Hybrid Electrical Vehicles	10 Hrs
Introduction - System Overview - Power train architecture - Parallel, Series and Combined - Types of xEVs - Vehicle layout and packaging options. - Energy devices & combinations - examples & Case Studies - Environmental Impact - Regulatory Issues (CO ₂ gas and particulate emissions) - Duty Cycles in Indian cities; performance (off cycle, durability) - Sustainability assessment; cradle to grave environmental impact.	

TEXTBOOKS:

1. Iqbal Husain, "Electric and Hybrid Vehicles –Design Fundamentals", CRC Press
2. Mehrdad Ehsani, Yimin Gao, Sebastian E.Gsay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell vehicles-Fundamentals - Theory and Design", CRC Press

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REFERENCES:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 2003
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3609					
TITLE OF THE COURSE	NOISE, VIBRATION AND HARSHNESS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	--	-	-	42	3

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES:

- To understand the fundamentals of sound and its measurement.
- Develop knowledge in finite element-based formulation for eigenvalue, frequency response, and transient dynamic problems
- Develop knowledge in modal and direct frequency response approaches used for the solution of vibration problems
- Learn applications of FEA and optimization to solve dynamic problems for vibration attenuation and noise reduction
- To know the most dominant sources of noise and vibration in cars, the dominant transmission paths including their relative importance at different driving conditions.
- To get an overview of state-of-the art in Computer Aided Engineering applied to NVH together with examples of NVH issues treated by CAE and to understand the limitations of the models used.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the fundamentals of sound and its measurement.	L2
CO2	Demonstrate of FEA tools solve dynamic problems for vibration.	L3
CO3	Execute forced harmonic and transient dynamic response studies by using dampening methods.	L2
CO4	Apply the knowledge ssources of vehicle vibration and vibration isolation techniques.	L3
CO5	Develop knowledge on advanced topics in finite element based NVH optimization	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Fundamentals of sound:	

Definition of NVH, Vehicle noise - Direct sound generation mechanism: airborne sound; Indirect sound generation mechanism: structure borne sound; Subjective response sound, Acoustic variables, basic attributes of sound such as wavelength, period, frequency; speed of sound, Decibel scale, Wave equation, types of sound fields, Measures of sound: Sound pressure, sound intensity and sound power, Combining sources: dB arithmetic, Standing wave, Beating, Impedance, Human hearing: frequency Versus sound pressure level, Loudness: phons and sones as noise descriptors; Weighting networks, Leq and various noise metrics for road noises.

MODULE 2	10Hrs

Finite element formulation for 1D and 2D eigenvalue problem
 Introduction to Hamilton's principle; Principle of minimum potential energy; stresses and equilibrium; strain displacement relationship; stress strain relationship ; special cases - 1D and 2D problems; natural coordinate system; element and global stiffness & mass matrix for 1D & 2D spring, truss, beam elements, 2D CST element, quadrilateral element; element and global stiffness & mass matrix for 1D & 2D spring, truss, beam elements, 2D CST element, quadrilateral element; harmonic loads- wheel unbalance, speed breakers, harmonic loads- wheel unbalance, speed brakers, and engine unbalance; real eigenvalue problem formulation; orthogonal properties of eigenvectors; Raleigh quotient; generalized mass, stiffness and force vector; consistent mass matrix and lump mass matrix; rigid body modes

MODULE 3	08Hrs

Damping & forced harmonic and transient dynamic response analyses
 Modal damping, Raleigh Damping, structural damping; mathematical modeling of elastomers with static and dynamic stiffness with frequency dependent characteristics;
 Mode superposition method and direct method for solution of forced harmonic and transient dynamic analyses; physical verses modal coordinates; modal mass, modal stiffness, & modal force; cut-off frequency for solution of low frequency NVH problems; Nyquist rule

MODULE 4	08Hrs

Sources of Vehicle vibration:
 Power train and Engine vibrations; driveline vibrations; chassis and suspension vibrations; Control strategies; Human response to vehicle vibrations, concept of harshness; subjective and objective evaluation of vehicle harshness. 6
Vibration Isolation and Control:
 Introduction; damping of vibrations; vibration isolation and absorption; design of a Vibration Absorbers, unconstrained and constrained layer damping treatment, add on dampers and stiffeners, Introduction to Active Vibration Control.

MODULE 5	08Hrs

Advanced topics in finite element based NVH optimization
 Modal alignment; point mobility analysis; transfer function analysis; vibroacoustic - applications of fluid-structure interaction to predict noise and vibration using finite element software; applications of topology and sizing optimization for automotive problems.

TEXT BOOKS:	
1.	Finite element analysis, P. Sheshu, PHI Learning Pvt. Ltd., New Delhi
2.	Kinsler, L.E., Frey, A.R., Coppens, A.B. and Sanders, J.V., 2000. Fundamentals of acoustics. John wiley & sons.

3.	Mathew Harrison Vehicle Refinement- Controlling Noise & Vibration in Road Vehicles, Elsevier Publication(2004).
4.	Introduction to optimal design, J.S. Arora, 4th edition, Elsevier Science Publishing Co. Inc

REFERENCES:	
1.	Theory and Problems of Mechanical Vibrations - William W. Seto, McGraw Hill International BookCo., Singapore (Schaum's outline series)
2.	Mechanical Vibrations - S. S. Rao, Pearson Education Inc.,
3.	Mechanical Vibrations - S. Graham Kelly, Schaum's Outline Series, Tata McGraw Hill Publishing Co.Ltd., New Delhi.
4	Finite element procedures, K.J. Bathe, Prentice-Hall

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3610					
TITLE OF THE COURSE	Experimental Methods for Mechanical Engineers					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The " Experimental Methods for Mechanical Engineers " course provides a comprehensive exploration of fundamental concepts and practical applications of experimental techniques within the field. Throughout the course's modules, students are exposed to a structured learning journey that equips them with the necessary skills and knowledge to proficiently plan, execute, analyze, and communicate experimental findings.

COURSE OBJECTIVES:

The objectives of the course are:

1. Understand and apply mechanical experimental methods effectively.
2. Proficiently use instruments for accurate data collection and analysis.
3. Design experiments, analyze data, optimize outcomes through statistical methods.
4. Integrate advanced techniques, simulations for comprehensive problem-solving.
5. Communicate findings ethically and clearly through reports and presentations.

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COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Compare and contrast different experimental design methods and their applications.	L3
CO2	Critically assess experimental designs and propose modifications for enhanced outcomes	L2
CO3	apply statistical tools, such as mean, standard deviation, and hypothesis testing, to analyze experimental data critically	L3
CO4	Synthesize experimental data, simulations, and literature to propose innovative solutions.	L3
CO5	Develop effective communication of experimental procedures and outcomes in written reports.	L3

COURSE CONTENT:	
MODULE 1 Introduction to Experimental Methods	08 hours
Introduction to the significance of experimental methods in mechanical engineering. Steps in the experimental process: formulation, design, execution, analysis, and conclusion. Role of uncertainty and error analysis. Ethics and safety considerations in conducting experiments. Overview of measurement systems, instruments, and sensors used in experiments.	
MODULE 2 Measurement Techniques and Instrumentation	10 hours
Principles of measurement: accuracy, precision, resolution, range. Selection and use of instruments: thermocouples, strain gauges, pressure transducers, accelerometers. Data acquisition systems and signal conditioning. Calibration procedures and techniques for ensuring measurement accuracy.	
MODULE 3 Design of Experiments and Statistical Analysis	08 hours
Factors affecting experimental design: objectives, variables, constraints, interactions. Full factorial, fractional factorial, and Taguchi methods for experimental design. Statistical analysis: mean, standard deviation, confidence intervals, hypothesis testing, regression analysis. Case studies illustrating the application of experimental design and statistical analysis.	
MODULE 4 Data Analysis and Interpretation	08 hours
Techniques for data reduction, visualization, and graphical representation. Error analysis and propagation of uncertainties in experimental measurements. Curve fitting and analysis of experimental data using software tools. Introduction to response surface methodology and optimization techniques. Case studies involving data analysis and interpretation of experimental results.	
MODULE 5 Advanced Experimental Techniques and Applications	08 hours
Exploration of advanced techniques: non-destructive testing, image analysis, acoustic measurements. Integration of computational simulations with experimental data. Real-world case studies showcasing experimental methods in mechanical engineering applications. Importance of effective communication: report writing, documentation, and presentation of experimental findings.	

TEXTBOOKS:

1. J.P. Holman, Experimental Methods for Engineers, McGraw-Hill Education, 2017.
2. Anthony Wheeler, Ahmad Ganji, Introduction to Engineering Experimentation, Pearson, 2010

REFERENCES:

1. C. Suryanarayana, Experimental Techniques in Materials and Mechanics, CRC Press, 2011
2. A. W. Hendry, Elements of Experimental Stress Analysis t, Elsevier Science, 2013.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3611					
TITLE OF THE COURSE	Rapid tooling and industrial Applications					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES :

- Identify different rapid tooling methods and their underlying principles
- Summarize the steps involved in various rapid tooling processes
- Illustrate how rapid tooling fits into the broader context of agile manufacturing strategies.
- Analyse the potential challenges and risks associated with implementing rapid tooling in a manufacturing setting.
- Compare and contrast the cost-effectiveness and efficiency of rapid tooling methods for different types of products.

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COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Describe the specific product types for which each rapid tooling method is suitable	L1
CO2	Describe how the various steps in rapid tooling processes contribute to the overall efficiency and accuracy.	L2
CO3	List the key characteristics that define an agile manufacturing approach..	L3

CO4	Demonstrate the ability to identify specific manufacturing scenarios where rapid tooling may face obstacles.	L3
CO5	Describe the variables that influence the selection of a specific rapid tooling method for a given product.	L2

COURSE CONTENT:		
MODULE 1		6Hrs
Introduction to Rapid Tooling and its Principles Rapid tooling and its significance in modern manufacturing. Injection moulding, CNC machining, 3D printing, etc. Principles underlying each method: Material selection, tool design, process parameters.		
MODULE 2		8 Hrs
Steps Involved in Rapid Tooling Processes Prototyping, tool fabrication, production. Sequential steps and their significance: Design, material selection, mould fabrication, testing. Mapping steps for specific rapid tooling methods.		
MODULE 3		6 Hrs
Agile Manufacturing and Integration of Rapid Tooling Agile manufacturing and its core principles. Explain the significance of agility in responding to market demands. Briefly discuss how agile manufacturing enhances competitiveness. Flexibility, adaptability, customer-centricity. Agile manufacturing in different industries. Rapid tooling aligns with agile manufacturing principles. Emerging trends and technologies in rapid tooling for agile manufacturing.		
MODULE 4		6 Hrs
Challenges and Risks in Rapid Tooling Implementation Importance of identifying and mitigating challenges. Technical challenges in rapid tooling issues related to tooling design complexities and precision. Implementation material selection impacts		

tool durability and quality. Economic challenges associated with rapid tooling. Present strategies for mitigating challenges and risks in rapid tooling. Role of research, planning, and process optimization. Emerging technologies and trends that may impact rapid tooling's challenges and solutions.	
MODULE 5	6 Hrs
Cost-Effectiveness and Efficiency in Rapid Tooling Methods Cost-effectiveness and efficiency in the context of rapid tooling. Significance of evaluating these factors in manufacturing. Role of rapid tooling in streamlining production processes. Key factors influencing the cost-effectiveness of rapid tooling. Initial investment costs, material expenses, and production volume. Relationship between costs and return on investment (ROI).	

TEXT BOOKS :

5. Frank W. Liou (2007). "Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development", CRC Press
6. Chua Chee Kai, Leong Kah Fai, Lim Chu Sing (2003). "Rapid Prototyping: Principles and Applications". World scientific publishing company

REFERENCES :

7. R K jain. "Tool Engineering and design: A Practical Approach", allied publishers, Mumbai.
8. G. R. Nagpal "Tool Engineering" (2009) Khanna publishing house, New Delhi.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3612					
TITLE OF THE COURSE	FUNDAMENTALS OF DRIVES AND DC MACHINE MODELLING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	--	-	-	42	3

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES:

- Comprehend Drive Systems Fundamentals.
- Analyze DC Machine Operation.
- Explore Drive Control Strategies.
- Model and Simulate DC Machines.
- Examine Drive System Components.
- Apply Knowledge in Practical Scenarios.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the foundational concepts of drive systems, including power electronics and motor control principles.	L2
CO2	Analyze the operation and behavior of DC machines in various load conditions.	L3
CO3	Apply different control strategies to electric drives for achieving desired performance characteristics.	L2
CO4	Model and simulate DC machines to predict and analyze their behavior under different operating conditions.	L3
CO5	Evaluate the interaction and function of drive system components, such as power converters and sensors, in achieving efficient operation.	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Module 1: Introduction to Electric Drives and DC Machines Introduction to electric drives, highlighting their significance in various industries. Additionally, it covers the fundamental aspects of DC machines, encompassing their diverse types, construction, and characteristic behaviors.	
MODULE 2	10Hrs

Power Electronics and Control Strategies Principles of power electronics as applied in electric drive systems. This is followed by an exploration of control strategies that are pivotal in governing the behavior of these drives. The module provides insights into both open-loop and closed-loop control techniques, illustrating their role in enhancing system performance.	
MODULE 3	08Hrs
Modeling and Analysis of DC Machines Mathematical modeling of DC machines, enabling students to understand the intricacies of their operations. It further delves into the analysis of DC machine behavior across a spectrum of load conditions, facilitating a comprehensive comprehension of their characteristics.	
MODULE 4	08Hrs
Control Techniques and Drive Components Control techniques employed within electric drives. Moreover, it critically examines the integral components of drive systems, including converters, sensors, and feedback devices. This exploration sheds light on their individual roles and collective contributions to the drives overall efficiency and functionality.	
MODULE 5	08Hrs
Simulation and Practical Applications Simulation techniques that predict DC machine behavior. Real-world application of control strategies, emphasizing their role in achieving specific performance objectives.	

Textbook for Fundamentals of Drives:

"Power Electronics and Variable Frequency Drives: Technology and Applications" by Bimal K. Bose

"Electric Machinery and Transformers" by Bhag S. Guru, Huseyin R. Hiziroglu

Reference books:

"Electric Machinery Fundamentals" by Stephen J. Chapman

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"Power Electronics: Converters, Applications, and Design" by Ned Mohan, Tore M. Undeland, William P. Robbins

Open Electives:

SEMESTER	VI					
YEAR	III					
COURSE CODE	21OE0017					
TITLE OF THE COURSE	ROBOTICS ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To introduce the basic concepts, parts and types of robots.
- To make the student familiar with the various sensors, drive systems in robots and programming.
- To discuss about the various applications, justification and implementation of robot.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic principles of Robotic technology, configurations, control and programming of Robots	L2
C02	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
C03	To choose the appropriate Sensor and Machine vision system for a given application	L3 7
C04	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
C05	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material	

transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	08Hrs
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	08Hrs
Drive system, control system, robot drive mechanisms, hydraulic - electric - servomotor- stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	08Hrs
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	08Hrs
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS :

1. AshitavaGhosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES :

1. Fu, K. S, Gonzalez, R. C, Lee, C.S.G, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987
2. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	VI					
YEAR	III					
COURSE CODE	21OE0018					
TITLE OF THE COURSE	PRODUCT DESIGN AND MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To expose the students the basics of product design and manufacturing.
- To introduce students to the basic principles and evaluation methods of various aspects of designing components.
- To teach students about the Industrial manufacturability requirements.
- To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Analyse the product life cycle phases of any product and suggest appropriate strategies	L2
C02	Construct product planning and specification documents	L3
C03	Demonstrate the knowledge of Architectural and Industrial design aspects of product design	L3
C04	Apply design for excellence (DF-X) concepts in product design	L37
C05	Choose an appropriate manufacturing process for product prototyping.	L4

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry -Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies	

MODULE 2	08Hrs
Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD) Product Specifications: specifications established, establishing target specifications, setting the final specifications, Case Studies	
MODULE 3	08Hrs
Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies	
MODULE 4	08Hrs
Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies	
MODULE 5	08Hrs
Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereolithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies.	

7

TEXT BOOKS :

1. A C Chitale and R C Gupta, Product Design and Manufacturing -, PH1, - 3rd Edition, 2003

REFERENCES :

1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development - McGraw Hill -2000.
2. Tim Jones, Butterworth Heinmann, New Product Development - Oxford. UCI - 1997
3. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002
3. .L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	V					
YEAR	III					
COURSE CODE	21OE0015					
TITLE OF THE COURSE	AUTOMOBILE ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To understand basics of Automobile Engineering & various automotive system.
- To understand vehicle layout, vehicle specifications & important of automobile.
- To make the student conversant with drive train & transmission.
- Understand the various Automobile Electrical System, Vehicle performance & their safety

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain components of automotive vehicle	L1
C02	Describe functioning of automotive transmission system	L1
C03	Calculate the resistance offered to the automobile by various factors	L2
C04	Describe various electrical components used in automobiles	L1 7
C05	Diagnosis the faults of automobile vehicles.	L2

COURSE CONTENT:	
MODULE 1	08Hrs s
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	

MODULE 1	08Hrs
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	
MODULE 2	08Hrs
Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission, Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive.	
MODULE 3	10Hrs
Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. Suspension: Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), damping and shock absorbers Brakes: Types of brake systems - drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.	
MODULE 4	08Hrs
Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise.	
MODULE 5	08Hrs
Batteries: Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods. Lighting System & Accessories: Insulated & earth return systems, positive & negative earth systems, electrical fuel pump, speedometer, fuel, oil & temperature gauges, horn, wiper system, trafficator, sensors and actuators, electronic control unit, traction control devices. Vehicle maintenance Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system.	

TEXT BOOKS :

1. William H. Crouse., "Automotive Mechanics", Tata McGraw Hill Publishing House.

REFERENCES :

1. K. Newton and W. Seeds, T.K. Garrett, "Motor Vehicle", 13th Edition, Elsevier publications
2. Hans Hermann Braess, Ulrich Seiffen, "Handbook of Automotive Engineering ", SAE Publications

SEMESTER	V					
YEAR	III					
COURSE CODE	21OE0016					
TITLE OF THE COURSE	RAPID MANUFACTURING TECHNOLOGIES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To provide knowledge of methods for the manufacturing of prototypes from computer based models
- To understand the entire process of direct manufacturing from the creation of computer based models to their physical realization
- To understand the various methods of manufacturing and their merits, demerits and applications
- To impart students to convert CAD models into real life engineering components

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the various rapid prototyping technologies ,	L1
C02	Select appropriate technology for product development	L2
C03	Describe rapid prototyping techniques	L1 7
C04	Analyse the quality of a product using rapid prototyping technique	L3
C05	Describe application of rapid prototyping	L1

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction- Need for the compression in product development, Historical development, Fundamentals of RP, Advantages and Classification of RP systems. Process chain, RP Data	

Formats, Information flow in an RP system.	
MODULE 2	10Hrs
Stereo lithography Apparatus (SLA): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Solid ground curing (SGC): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications.	
MODULE 3	10Hrs
Fused Deposition Modelling (FDM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Laminated Object Manufacturing (LOM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Ballistic Particle Manufacturing (BPM): Principle.	
MODULE 4	10Hrs
Selective laser sintering (SLS): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Three dimensional Printing (3DP): Principle, process parameters, process details, machine details, products, Advantages, Limitations, applications. Laser Engineering Net Shaping (LENS) -Principle. Concept modellers like thermal jet printers, Sander's model maker, GenisysXs 3D printers, JP system 5, Object Quadra system.	
MODULE 5	10Hrs
Introduction to rapid tooling: Direct soft tooling- casting molds, Direct AIM, composite tooling. Indirect soft tooling- spray metal molding, silicon rubber molds, Castable resin and ceramic molds. Direct hard tooling-rapid tool, Laminated metal tooling, DMLS tooling. Indirect hard tooling- 3D keltool, ED electrodes, Ecotool, copy milling. Applications: Application-Material Relationship, Applications in Design, Applications in Engineering, Analysis and Planning. Application of Rapid prototyping in biomedical, automotive, aerospace, jewellery and coin industries.	

TEXT BOOKS :

1. C. K.Chua, K. F.Leong and C. S.Lim, Rapid prototyping: Principles and applications, World Scientific Publishers, 2003

REFERENCES :

1. Andreas Gebhardt, Hanser , Rapid prototyping, Gardener Publications, 2003.
2. L.W.Liou, F.W. Liou, Rapid Prototyping and Engineering applications: A tool box for prototype development,

DAYANANDA SAGAR UNIVERSITY

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SCHOOL OF ENGINEERING



**SCHEME & SYLLABUS
FOR
BACHELOR OF TECHNOLOGY (B.Tech.) – 2021
MECHANICAL ENGINEERING
(MECH)**

**(3rd to 8th SEMESTER) (WITH EFFECT
FROM 2021 - 22)**

DEPARTMENT OF MECHANICAL ENGINEERING
PROPOSED SCHEME - B.TECH – 2021 -22 ONWARDS
SEMESTER V

Sl. No.	Course Code	Course	$\frac{AU}{CR}$	Scheme of Teaching					Scheme of Evaluation		Pre-requisite
				L	T	P	S/P	C	CIA	End Exam	
1	21ME3501	Heat Transfer	CR	03	--	02	--	04	60	40	21ME2304
2	21ME3502	Dynamics of Machines and Mechanism	CR	02	--	02	--	03	60	40	--
3	21ME3503	Design of Machine Elements	CR	03			--	03	60	40	21ME2302
4	21ME3504	Digital Manufacturing	CR	03	--	--	--	03	60	40	
5	21ME35XX	Professional Elective – I	CR	03	--	--	--	03	60	40	--
6	21ME35XX	Professional Elective – II	CR	03	--	--	--	03	60	40	
7	21OEXXXX	Open Elective – I	CR	03	--	--	--	03	60	40	--
8	21ME3505	Liberal Studies	CR	02	--	--		02	60	40	--
Grand Total 800				22	--	04	--	24	480	320	

PC- Professional Core, PE-Professional Elective, OE-Open Elective, LS-Liberal Science, CR – Credit, AU – Audit, CIA – Continuous Internal ssessment

PROFESSIONAL ELECTIVE -I			
S.No	Course Code	Course Title	Group
1	21ME3506	Introduction to robotics and Automation	ROBOTICS & AUTOMATION
2	21ME3507	Additive Manufacturing Technology	ADDITIVE MANUFACTURING
3	21ME3508	Introduction to Hybrid & Electric Vehicles	HYBRID & ELECTRIC VEHICLES
4	21ME3509	Refrigeration and Air Conditioning	GENERAL
5	21ME3510	Tool Design	

PROFESSIONAL ELECTIVE -II			
S.No	Course Code	Course Title	Group
1	21ME3511	Drives & Control systems	ROBOTICS & AUTOMATION
2	21ME3512	Electrical Machines and Power Systems	
3	21ME3513	Materials for Additive Manufacturing	ADDITIVE MANUFACTURING
4	21ME3514	Automotive Chassis & Transmission Systems	HYBRID & ELECTRIC VEHICLES
6	21ME3515	Renewable Energy Sources	

DEPARTMENT OF MECHANICAL ENGINEERING
PROPOSED SCHEME – B.TECH – 2021 -22 ONWARDS

SEMESTER VI

Sl. No.	Course Code	Course	$\frac{AU}{CR}$	Scheme of Teaching					Scheme of Evaluation		Pre-requisite
				Lecture	Tutorial	Practical	Seminar/Project	No of Credits	CIA	End Exam	
1	21ME3601	Machine Design Practice	CR	02	01	02	--	04	60	40	Mechanics of solids(IV)
2	21ME3602	Finite Element Analysis	CR	03	--	02	--	04	60	40	
3	21ME3603	Control Systems Engineering	CR	03	--	02	--	04	60	40	
4	21ME36XX	Professional Elective – III	CR	03	--		--	03	60	40	
5	21ME36XX	Professional Elective – IV	CR	03	--	--	--	03	60	40	--
6	21OEXXX	Open Elective – II	CR	03	--	---	---	03	60	40	--
7	21ME3604	Liberal Studies	CR	01	--	--	--	01	60	40	--
Grand Total 800				18	01	08	--	22	420	280	

PC- Professional Core, PE- Professional Elective, OE- Open Elective, LS-Liberal Science, CR – Credit, AU – Audit, CIA – Continuous Internal Assessment

PROFESSIONAL ELECTIVE -III			
S.No	Course Code	Course Title	Group
1	21ME3605	Robot Kinematics and Dynamics	ROBOTICS & AUTOMATION
2	21ME3606	Industrial Automation-I	
3	21ME3607	Computational Tools for Additive Manufacturing	ADDITIVE MANUFACTURING
4	21ME3608	HEV / EV System Design Architecture	HYBRID & ELECTRIC VEHICLES
5	21ME3609	NVH	

PROFESSIONAL ELECTIVE -IV			
S.No	Course Code	Course Title	Group
1	21ME3610	Experimental methods for Mechanical Engineers	ROBOTICS & AUTOMATION
2	21ME3611	Experimental methods for Mechanical Engineers	ADDITIVE MANUFACTURING
3	21ME3612	Rapid Tooling and Industrial Applications	
4	21ME3613	Fundamental of Drives and DC Machine Modeling	HYBRID & ELECTRIC VEHICLES

Categories of Courses for Liberal Studies

1. Physical Education: Sports, Yoga, Marathon/Jogging, NCC, Dance
2. Psychology: Positive Psychology, Mindfulness,
3. Linguistic and communication: **Technical Communication(2)**,, Public Speaking, Group Discussions Japanese, German, **kannada (1)**, Modern Indian Languages
4. Life Skills: Aptitude, Interview skills, Research methodology
5. Management, **Economics (2)** and Entrepreneurship courses
6. Volunteering/Community activities: NSS, cYaag
7. Arts and Creativity: Creative writing, Music, Performing arts,
8. Design: **Design Thinking (1)**, Engineering Design, Ergonomics
9. Liberal STEM: **Environmental Studies (2)**
10. Humanitie, Social Studies, History, **Indian Constitution (1)**,
11. Law Cyber Crimes, Security Policies and Law, **Law for Engineers (2)**,

MINORS FOR OTHER PROGRAMS				
Sl. No	Course Name	Credit Pattern (L:T:P)	Credits	Semester
1	Engineering Materials (Theory & Practice)	2 : 0 : 2	3	3
2	Solid Mechanics (Theory & Practice)	2: 0 : 2	3	4
3	Fluids & Thermal Engineering (Theory & Practice)	3: 0 : 2	4	5
4	Digital Manufacturing (Theory & Practice)	3 : 0 : 2	4	5
5	Product Design and development (Theory & Practice) -	2: 0 : 2	3	6
6	Recent Trends in Mechanical Engineering (Robotics, Automation & Hybrid Vehicles)	3: 0 : 0	3	7
		Total	20	

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3501					
TITLE OF THE COURSE	HEAT TRANSFER					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	inlar/Projects Hours	Total Hours	Credits
	3	-	2	-	39+26	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	--	--	--

COURSE OBJECTIVES:

To understand the basic phenomenon of heat transfer and its importance in engineering applications.

To enable the students to understand the different modes of heat transfer like conduction, convection and radiation.

To understand the mechanism of heat transfer under steady and transient conditions

To illustrate the applications of convective heat transfer including heat exchangers, boiling & condensation

To understand the different laws of radiation and applying for solving engineering problems

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's taxonomy Level
C01	Compute temperature distribution and heat flow in steady-state and unsteady-state 1-D heat conduction	L3
C02	Calculate forced and free convective heat transfer coefficient and rate of heat transfer	L3
C03	Analyze performance characteristics of heat exchangers	L4
C04	Calculate radiation heat transfer between objects with simple geometries	L3
C05	Demonstrate conduction, convection, and radiation heat transfer phenomena through experiments	L2

COURSE CONTENT:	
MODULE 1	08 Hrs

Modes of heat transfer: Basic laws governing conduction, Thermal conductivity. Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, discussion on 3-D conduction in cylindrical and spherical coordinate system. One dimensional conduction equations for plane, cylinder and spheres. Overall heat transfer coefficient, Thermal conductive resistance and numerical problems. Derivation for heat flow and temperature distribution in a plane for variable thermal conductivity case, critical thickness of insulation and numerical problems.	
MODULE 2	08 Hrs
Introduction, Heat transfer through rectangular fin, infinitely long fin, short fin with insulated tip and without insulated tips. FIN efficiency and effectiveness. Numerical problems. Transient Conduction: Lumped parameter analysis, use of transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, numerical problems	
MODULE 3	08 Hrs
Natural Convection: Introduction, laminar flow, momentum and energy equations for vertical flat plate, physical significance of Grashoff number, use of correlations for free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, numerical problems. Forced Convection: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems.	
MODULE 4	07 Hrs
Fundamental concepts of radiation, different laws governing radiation heat transfer, Stefan-Boltzman law, Kirchoff's law, Planck's law, Wein's displacement law, Intensity of radiation and Lambert's cosine law, Radiation shape factor, Heat exchange by radiation between two black and diffuse gray surfaces, radiation shields, numerical problems.	
MODULE 5	08 Hrs
Heat exchangers: Classification and applications, overall heat transfer coefficient, heat exchanger analysis-Logarithmic mean temperature difference for parallel and counter flow heat exchanger, effectiveness-number of transfer units, method for parallel and counter flow heat exchanger, introduction to cross flow heat exchanger, Logarithmic mean temperature difference correction factor. Numerical problems. Condensation and Boiling: Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation. (no numerical problems).	

List of Laboratory/Practical Experiments activities to be conducted (if any) :26Hrs	
1.	Determination of thermal conductivity of metal rod.
2.	Determination of thermal conductivity of composite wall.
3.	Experiment on transient conduction heat transfer.
4.	Determination of heat transfer coefficient in natural convection.
5.	Determination of heat transfer coefficient in forced convection.

6.	Determination of temperature distribution, fin efficiency in natural / forced Convection.
7.	Determination of emissivity of a test surface.
8.	Determination of the emissive power of black body using Stefan's Boltzmann's constant.
9.	Determination of effectiveness and logarithmic mean temperature difference in parallel flow and counter flow heat exchanger.

TEXT BOOKS:

1. Incropera, F.P. and DeWitt, D.P(2011). "Fundamentals of Heat and Mass transfer , John Wiley

REFERENCES:

1. Ozisik(2002.), Heat Transfer-A Basic Approach, Tata Mc Graw Hill.
2. P K Nag (2011), Heat and Mass Transfer, Tata McGrawHill
3. J P Holaman (2009), Heat Transfer, Tata McGrawHill.
4. C.P. Kothandraman, S. Subramanyan(2014), Heat and Mass Transfer Data Book, New Age International Publishers,

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3502					
TITLE OF THE COURSE	DYNAMICS OF MACHINES AND MECHANISM					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	inlar/Projects Hours	Total Hours	Credits
	2	-	2	-	26+26	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	--	--	--

COURSE OBJECTIVES:

Understand kinematics and motion analysis in machines.
Analyze dynamic forces and moments in mechanical systems.
Model and simulate mechanical systems' dynamic behavior.
Incorporate dynamics principles into effective mechanical design.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's taxonomy Level
C01	Apply kinematic principles to analyze and describe the motion of machine components accurately.	L3
C02	Analyze and predict dynamic forces, moments, and torques in various mechanical systems.	L3
C03	Develop mathematical models to simulate the dynamic behavior of machines and mechanisms.	L4
C04	Evaluate and optimize mechanical designs to minimize vibrations and oscillations.	L3
C05	Demonstrate proficiency in utilizing simulation software for dynamic analysis and visualization.	L2
C06	Integrate dynamic considerations into the design process to create efficient and reliable mechanical systems.	L3

COURSE CONTENT:	
MODULE 1	08 Hrs
Coordinate systems, motion analysis, and velocity relationships, along with delving into advanced kinematic analysis techniques.	

MODULE 2	08 Hrs
Dynamic forces, moments, and torques in mechanical systems. Effects of inertia, friction, and external loads on system behavior.	
MODULE 3	08 Hrs
Static and dynamic balancing. Balancing of single rotating mass by balancing masses in same plane and in different planes, balancing of several rotating masses by balancing masses in same plane and in different planes.	
MODULE 4	07 Hrs
Vibrations in machines and mechanisms. Different vibration types, their implications, and their effects on system stability and performance.	
MODULE 5	08 Hrs
Gyroscopic effects, which come into play in rotating systems, and an exploration of multi-degree-of-freedom systems. Application of dynamic analysis in designing industrial machinery and robotics.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :26Hrs	
1.	Free Vibration Analysis of a Beam
2.	Forced Vibration and Resonance in Mechanical Systems
3.	Balancing Rotating Machinery
4.	Impact and Collision Analysis
5.	Dynamic Behavior of Gear Trains
6.	Centrifugal Force and Effects on Rotating Systems
7.	Dynamic Analysis of Cam-Follower Mechanisms
8.	Torsional Vibration of Shafts
9.	Whirling of Shafts and Critical Speed Analysis

Textbooks:

"Mechanisms and Dynamics of Machinery" by Hamilton H. Mabie, Charles F. Reinholtz, - John Wiley & Sons 4th edition.

"Theory of Machines and Mechanisms" by Joseph E. Shigley, John J. Uicker Jr. Oxford University Press, 4th edition

References:

"Mechanical Vibrations" by Singiresu S. Rao , Pearson 6th edition

"Dynamics of Structures" by Anil K. Chopra , Pearson 4th edition

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3503					
TITLE OF THE COURSE	Design of Machine Elements					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	III		Engineering Materials

Summary:

This course provides an in-depth exploration of machine design principles and their applications in engineering. It covers the design process, stress analysis, failure theories, dynamic loading, threaded fasteners, and keys and couplings. Through a combination of theoretical discussions and practical examples, students will gain a comprehensive understanding of machine design and its significance in various engineering disciplines.

COURSE OBJECTIVES:

The objectives of the course are:

1. Understand design process stages to analyze and solve practical engineering problems.
2. Apply stress concentration factors effectively to evaluate potential failure points in machine designs
3. Apply stress analysis techniques to design machine components effectively for static and dynamic loading conditions.
4. Analyze the behavior of threaded fasteners under various loading conditions, such as static, dynamic, and impact loads.
5. Synthesize their knowledge of keys and couplings to design efficient power transmission systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyze the significance of machine design and its impact on safety and reliability.	L2
CO2	Apply stress analysis to machine components and make informed design decisions.	L3
CO3	Design machine components for dynamic loading and estimate fatigue life.	L3
CO4	Evaluate threaded fasteners and design for static, dynamic, and impact loads.	L3
CO5	Design keys and couplings for power transmission applications	L3

COURSE CONTENT:

MODULE 1: Introduction to Machine Design	07 Hrs
Introduction to machine design and its significance in engineering. Design process and its stages. Consideration of factors like safety, reliability, and economics in machine design. Materials and Manufacturing Processes. Overview of various manufacturing processes and their impact on design. Heat treatment processes and their significance in machine component design	
MODULE 2: Stress Analysis and Failure Theories	08 Hrs
Concepts of stress and strain, principal stresses. Introduction to stress concentration factors and their influence on machine component design. Introduction to failure theories. Application of stress concentration factors and failure theories in the design of machine components.	
MODULE 3: Dynamic Loading	08 Hrs
Design for static loading and the role of stress concentration factors. RR Moore Fatigue Test. Design for fatigue loading and fatigue life estimation.	
MODULE 4: Threaded fasteners	08 Hrs
Stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints.	
MODULE 5: Keys and couplings	08 Hrs
Overview of keys and couplings in mechanical engineering. Importance of keys and couplings in power transmission. Design of flange and flexible couplings.	

Text Books:

1. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.
2. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition, 2007.

Reference Books:

1. Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.
2. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.
3. K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.
4. K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3504					
TITLE OF THE COURSE	Digital Manufacturing					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- Understand Digital Manufacturing Concepts.
- Develop Proficiency in CAD and CAM Tools.
- Integrate Digital Prototyping and Simulation.
- Implement Industry 4.0 and Automation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Apply CAD software to create and modify 3D models for manufacturing purposes.	L2
C02	Utilize CAM tools to generate toolpaths and optimize machining strategies.	L3
C03	Perform virtual testing and simulation to validate designs and manufacturing processes.	L3
C04	Identify opportunities for automation and implement Industry 4.0 principles in manufacturing settings. 1	L3
C05	Analyze the benefits and limitations of digital manufacturing methods compared to traditional approaches.	L3
C06	Develop a practical understanding of additive manufacturing techniques and their applications in various industries.	L3

COURSE CONTENT:

MODULE 1: Introduction to Digital Manufacturing	07 Hrs
Introduction to Digital Manufacturing Cover the basics of digital manufacturing, its significance in modern industry, and a comparison with traditional manufacturing methods. Explore the evolution of manufacturing technologies and the role of digital tools in optimizing production processes.	

MODULE 2: Computer-Aided Design (CAD) and 3D Modeling	08 Hrs
Focus on CAD software tools and techniques for creating detailed 3D models. Teach students how to design parts and assemblies, apply constraints, and generate engineering drawings. Emphasize parametric modeling and design for manufacturability.	
MODULE 3: Computer-Aided Manufacturing (CAM) and Toolpath Generation	08 Hrs
Introduce CAM software and its role in translating CAD designs into machine instructions. Cover toolpath generation, machining strategies, and optimizing cutting parameters. Provide practical exercises for generating efficient toolpaths for different manufacturing processes.	
MODULE 4: Digital Prototyping and Simulation	08 Hrs
Explore digital prototyping and simulation tools to validate designs and predict manufacturing outcomes. Teach students how to simulate machining operations, analyze material removal, and ensure collision-free toolpaths. Discuss the advantages of virtual testing in reducing errors and minimizing production costs.	
MODULE 5: Industry 4.0 and Automation in Manufacturing	08 Hrs
Examine the integration of digital technologies and automation in manufacturing environments. Cover topics such as the Industrial Internet of Things (IIoT), smart factories, data analytics, and robotics. Discuss real-world applications and case studies showcasing the implementation of Industry 4.0 principles.	

Text Books:

"Digital Manufacturing: Principles, Systems, and Technologies" Author: Ben Wang, Publisher: CRC Press, Edition: 1st Edition

Computer-Aided Manufacturing" Author: Tien-Chien Chang, Richard A. Wysk, Hsu-Pin Wang
Publisher: Pearson Edition: 1st Edition.

Reference Books:

1

- "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing" by Ian Gibson, David Rosen, and Brent Stucker.
- "Manufacturing Processes for Engineering Materials" by Serope Kalpakjian and Steven Schmid.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3506					
TITLE OF THE COURSE	Introduction to robotics and Automation					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Introduction to Robotics and Automation course provides a comprehensive overview of the fundamental concepts, principles, and technologies that underlie the field of robotics and automation. Through a combination of theoretical exploration and practical applications, participants will develop a solid understanding of robot anatomy, configurations, kinematics, drive systems, sensors, control mechanisms, and trajectory planning. This course aims to equip participants with the knowledge and skills needed to comprehend, design, and work with robotic systems and automation technologies in diverse industries.

COURSE OBJECTIVES:

The objectives of the course are to:

1. To introduce the basic concepts, parts and types of robots.
2. To make the student familiar with the various sensors, drive systems in robots and programming.
3. To discuss about the various applications, justification and implementation of robot.

1

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic principles of Robotic technology configurations, control and programming of Robots	L2
C02	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
C03	To choose the appropriate Sensor and Machine vision system for a given application	L3
C04	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
C05	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	08Hrs
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	08Hrs
Drive system, control system, robot drive mechanisms, hydraulic – electric – servomotor-stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	08Hrs
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	08Hrs
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS:

1. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES:

1. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004..
2. Richard D. Klafter, Robotic Engineering, Prentice Hall of India Pvt., Ltd., 2001.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3507					
TITLE OF THE COURSE	Additive Manufacturing Technology					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	23	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Additive Manufacturing Fundamentals and Applications course provides a comprehensive introduction to the world of additive manufacturing (AM), commonly known as 3D printing. This course is designed to equip participants with a deep understanding of AM processes, technologies, machine systems, pre-processing, and post-processing techniques. Through a balanced blend of theoretical knowledge and practical insights, participants will gain the necessary skills to leverage additive manufacturing in various industries such as rapid prototyping, rapid manufacturing, rapid tooling, and more.

COURSE OBJECTIVES:

The objectives of the course are to:

1. Understand the importance of additive manufacturing in advance manufacturing process.
2. Explore the potential of additive manufacturing in different industrial sectors
3. Acquire knowledge, techniques and skills to select relevant additive manufacturing process.
4. Apply 3D printing technology for additive manufacturing
5. Exploit the technology used in additive manufacturing

2

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the working principles and process parameters of additive manufacturing processes	L2
CO2	Explore different additive manufacturing processes and suggest suitable methods for building a particular component	L1
CO3	Perform suitable Pre & post processing operation based on product repair requirement	L4
CO4	Design and develop a working model using additive manufacturing Processes	L6
CO5	Able to identify, analyze and solve problems related to Additive Manufacturing	L3

COURSE CONTENT:	
MODULE 1: INTRODUCTION TO ADDITIVE MANUFACTURING	06Hrs
Introduction to AM, AM evolution, Historical development, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM.	
MODULE 2: ADDITIVE MANUFACTURING PROCESSES	09Hrs
Types, Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).	
MODULE 3: ADDITIVE MANUFACTURING MACHINES AND SYSTEMS	09Hrs
Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors. Introduction to NC/CNC/DNC machine tools, CNC programming and introduction, Hardware Interpolators, Software Interpolators, Recent developments of CNC systems for additive manufacturing.	
MODULE 4: PRE-PROCESSING IN ADDITIVE MANUFACTURING	09Hrs
Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.	
MODULE 5: POST-PROCESSING IN ADDITIVE MANUFACTURING	09Hrs
Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing, Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.	

TEXT BOOKS:

- . Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
- . Gibson, I, Rosen, D W., and Stucker,B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010

REFERENCES:

- . Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007
- . Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
- . Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3508					
TITLE OF THE COURSE	Introduction to Hybrid & Electric Vehicles:					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	39	3

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

Understand Vehicle Electrification Concepts.

Explore Powertrain Components and Integration.

Analyze Energy Management and Efficiency.

Evaluate Environmental and Economic Impacts.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply knowledge of hybrid, plug-in hybrid, and electric vehicle technologies to differentiate their operational principles and characteristics.	L2
CO2	Utilize understanding of powertrain components to analyze the integration of electric motors, batteries, and internal combustion engines in vehicle propulsion systems.	L3
CO3	Apply energy management strategies to optimize power distribution between electric and internal combustion sources, considering driving conditions and battery state of charge.	L3
CO4	Assess the environmental impact of hybrid and electric vehicles by analyzing their contribution to reduced emissions and energy consumption.	L3
CO5	Demonstrate the application of power electronics for efficient energy conversion and management in hybrid and electric vehicle systems.	L3
CO6	Formulate informed discussions on economic aspects, incentives, and market dynamics related to hybrid and electric vehicles within the context of sustainable transportation solutions.	L3

COURSE CONTENT:

MODULE 1: Basics of Electrified Vehicle Technologies	07 Hrs
Fundamental concepts of hybrid, plug-in hybrid, and electric vehicles. The comparison between conventional and electrified powertrains will be discussed, along with the historical	

development and significance of electrified vehicles.	
MODULE 2: Electric Powertrain Components and Integration	08 Hrs
includes an in-depth look at electric motors and their classifications. Battery types, characteristics, and technologies will also be explored. Additionally, we will examine the integration of electric components with internal combustion engines and the role of power electronics and inverters in electrified powertrains.	
MODULE 3: Energy Management and Efficiency Strategies	08 Hrs
Focuses on energy management algorithms used in hybrid and electric vehicles. Concepts of regenerative braking and energy recovery systems. Analyze driving conditions and battery state impact energy efficiency. Thermal management considerations for hybrid and electric systems.	
MODULE 4: Environmental and Economic Considerations	08 Hrs
Electrified vehicles in reducing emissions. The concept of life cycle assessment and environmental impact analysis will be explored. Economic factors, incentives, and the total cost of ownership for hybrid and electric vehicles. Market trends, consumer adoption, and regulatory policies.	
MODULE 5: Industry 4.0 and Automation in Manufacturing	08 Hrs
Advancements in battery technology and energy storage. Potential of electrified vehicles to contribute to smart grids and vehicle-to-grid (V2G) systems. Possibilities of hydrogen fuel cells and alternative energy sources. Integration of autonomous and connected features in electrified vehicles.	

Text Books:

Electric and Hybrid Vehicles: Design Fundamentals", Iqbal Husain, CRC Press, 2nd Edition.
Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, 2nd Edition.

Reference Books:

2

Electric Vehicle Technology Explained" by James Larminie, John Lowry
"Hybrid and Electric Vehicles: Innovations, Developments, and Technologies" by Magdi S. Mahmoud

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3509					
TITLE OF THE COURSE	REFRIGERATION AND AIR CONDITIONING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Refrigeration and Air Conditioning Systems course delves into the fundamental principles, methodologies, and applications of refrigeration and air conditioning technologies. Participants will gain a comprehensive understanding of various refrigeration methods, refrigerants, system cycles, and psychrometric processes. Through a combination of theoretical concepts and practical insights, this course equips participants with the knowledge and skills needed to design, analyze, and optimize refrigeration and air conditioning systems for diverse settings.

COURSE OBJECTIVES:

The objectives of the course are to:

1. Study the methods of refrigeration, Carnot cycle, Unit of refrigeration and coefficient of performance
2. Discuss classification and properties of refrigerants
3. Describe the Vapour compression and Vapour absorption systems
4. Understand psychrometric properties and processes
5. Study Air conditioning systems and air conditioning loads
6. Understand the measuring instruments and sensors used in air conditioning

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain different methods of refrigeration	L2
CO2	Select the suitable refrigerant based on application and environmental consideration	L3

C03	Analyse Vapour compression and Vapour absorption refrigeration systems	L4
C04	Apply the knowledge of psychrometric properties and processes for air conditioning	L3
C05	Compute air conditioning loads and Interpret airconditioning methods	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Methods of refrigeration, ice refrigeration, evaporative refrigeration, air refrigeration, vapour refrigeration, dry ice refrigeration, pulse tube refrigeration, thermo-acoustic refrigeration, reverse Carnot cycle, block diagram of refrigerator & modified reverse Carnot cycle (Bell Coleman cycle). Unit of refrigeration and coefficient of performance.	
MODULE 2	08Hrs
Refrigerants: Classification of refrigerants, desirable properties of refrigerants, environmental issues, Ozone depletion potential and global warming potential & life cycle climate performance. Selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes.	
MODULE 3	10Hrs
Vapour Compression Systems: Vapor compression cycle: p-h and T-s diagrams – deviations from theoretical cycle – sub cooling and super heating-effects of condenser and evaporator pressure on COP- multi pressure system – low temperature refrigeration – cascade systems – problems. Vapour Absorption Systems: Introduction, working of simple vapour absorption system, desirable properties of binary mixture (aqua-ammonia), Lithium-Bromide (Li- Br) absorption system, performance evaluation, applications and comparison between vapour compression system and vapour absorption system.	
MODULE 4	08Hrs
Properties of moist air-Gibbs Dalton law, specific humidity, dew point temperature, degree of saturation, relative humidity, enthalpy, humid specific heat, wet bulb temperature thermodynamic wet bulb temperature, psychrometric chart; psychrometric processes.	

MODULE 5	08Hrs
Air conditioning: Introduction, Classification, ASHRAE Nomenclature, Applications, Different Air-Conditioning Systems: Central, Unitary, Window, Packaged & Transport Air conditioning loads: Outside and inside design conditions; Sources of heat loads and calculations; Air filters; air conditioning systems with controls: temperature, pressure and humidity sensors, actuators & safety controls.	

TEXT BOOKS :

1. Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill, 2008.
2. Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 1983.

REFERENCES :

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000
2. Domkundwar, V.M (2014), Refrigeration and Air-Conditioning Data Book, Dhapapatraihill, 1998.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3510					
TITLE OF THE COURSE	TOOL DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Tool Design course offers a comprehensive exploration of tooling materials, cutting tool design, pressworking, injection molding, and jig and fixture design, all under the overarching theme of efficient and effective tool design. Through a combination of theoretical concepts and practical case studies, participants will develop a deep understanding of tooling principles, design methodologies, and their practical applications in various manufacturing processes.

COURSE OBJECTIVES:

The objectives of the course are to:

1. To understand the various types of tooling materials and their industrial applications.
2. To develop capability to design and select single point and multipoint cutting tools for various machining operations.
3. Exposure to variety of locating and clamping methods available.
4. To enable the students to design jigs and fixtures for simple components
5. To expose the students to the design/selection procedure of sheet metal and injection mold

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Select appropriate cutting tools required for producing a component.	L2
CO2	Apply design concepts of single point and multi-point cutting tools	L3
CO3	Demonstrate knowledge of various press tools and sheet tool operations.	L2
CO4	Classify and explain various types of injection moulding dies.	L4
CO5	Analyze and design a jig/fixture for a given simple component	L4

COURSE CONTENT:	
MODULE 1	08Hrs
Different tooling materials: cemented carbides, coated carbides, cermet's, ceramics and polycrystalline tool materials. Selection and properties of tool materials, plastics as tool materials, Tooling materials – properties and applications of ferrous, non-ferrous and non-metallic materials. Case studies.	
MODULE 2	08Hrs
Design of single point cutting tools - various systems of specifications, geometry and their interrelation, theories of formation of chip and their effect. Design of multipoint cutting tools – Design elements, nomenclature and geometry of drill bit, milling cutter, reamer and broaching tool. Cutting parameters and machining time calculation for drilling, milling, reaming and broaching operation. Case studies	
MODULE 3	10Hrs
Working of a power press and classification of presses. Press working terminology, Types of dies-Simple, progressive, compound and combination dies. Components of a simple die, press tool operation, die accessories, press tool operations. Shearing theory, cutting clearance between punch and die, methods of reducing cutting forces, Centre of pressure and problems, scrap strip layout. Design problems on blanking and piercing dies for simple components. Case studies	
MODULE 4	08Hrs
Injection moulding machine and its elements, general configuration of a two plate mould. Introduction to gate, runner, parting surface, ejection system. Core and cooling system. Design problems on injection mold. Case studies	
MODULE 5	08Hrs
Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures. Location: 3-2-1 Principle of location, different types of locating elements. Clamping: Principles of clamping, types of clamping devices.	
Drill jigs: Different types, Types of fixtures: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centres, and modular fixtures. Case studies.	

TEXT BOOKS :

1. Donaldson. C, Lecain.G.H and Goold.V.C, Tool Design, Tata McGraw Hill publishing company limited, New Delhi, 2002.

REFERENCES :

1. Surendra Kenav and Umesh Chandra, Production Engineering Design (Tool Design), New Delhi, 1994.
2. Mehtha.N.K, Machine Tool Design and Numerical Control, Tata Mc-Graw Hill, Third Edition, 2012.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3511					
TITLE OF THE COURSE	Drives & Control systems					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

Understand principles of drive systems.

Analyze control strategies for drive systems.

Study drive system components.

Apply knowledge to practical applications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply principles of drive systems to analyze and design various types of mechanical and electrical drive setups.	L2
CO2	Implement different control strategies to achieve desired performance characteristics in drive systems.	L3
CO3	Evaluate the impact of drive system components on overall system behavior and efficiency.	L3
CO4	Design and simulate control algorithms for closed-loop drive systems to achieve specific speed, torque, and position requirements.	L3
CO5	Troubleshoot and diagnose issues in drive and control systems, implementing corrective measures as needed.	L3
CO6	Integrate theoretical knowledge and practical skills to optimize drive systems for diverse industrial and technological applications.	L3

COURSE CONTENT:

MODULE 1: Introduction to Drive Systems and Control	07 Hrs
Provides an introduction to drive systems and their wide-ranging applications. It covers the distinctions between mechanical and electrical drive systems and introduces control strategies, including open-loop and closed-loop control approaches.	
MODULE 2: Electric Motors and Power Electronics	08 Hrs

Electric motors and their types, such as DC, AC induction, and synchronous motors. Additionally, the module delves into the role of power electronics in drive systems, explaining how motor control techniques like voltage and current control are applied.	
MODULE 3: Sensors and Feedback Devices	08 Hrs
Control algorithms, primarily focusing on Proportional-Integral-Derivative (PID) control techniques. It also covers advanced strategies like Field-Oriented Control (FOC) applied to electric motors, and introduces adaptive and predictive control techniques.	
MODULE 4: Control Algorithms and Strategies	08 Hrs
Emphasizes the integration of drive components into comprehensive systems. It discusses industrial applications where drive systems play a pivotal role and provides insights into emerging trends in drive technology.	
MODULE 5: System Integration and Applications	08 Hrs
Integration of drive components into comprehensive systems. It discusses industrial applications where drive systems play a pivotal role and provides insights into emerging trends in drive technology	

Text Books:

"Electric Drives", Ion Boldea, S.A. Nasar, CRC Press, 3rd Edition
"Control of Electric Machine Drive Systems", Seung-Ki Sul, Wiley , 1st edition.

Reference Books:

"Electric Motor Drives: Modeling, Analysis, and Control" by R. Krishnan
"Electric Drives and Electromechanical Systems: Applications and Control" by Richard Crowder, Tim Marks

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3513					
TITLE OF THE COURSE	MATERIALS FOR ADDITIVE MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Materials for Additive Manufacturing course offers a comprehensive exploration of the crucial role that materials play in the rapidly evolving field of additive manufacturing (AM). Through a combination of theoretical insights, practical case studies, and emerging trends, participants will gain a deep understanding of material selection, design considerations, mathematical modeling, and a diverse array of applications in industries ranging from biomedical to aerospace.

COURSE OBJECTIVES:

The objectives of the course are to:

1. Understand the importance of materials in additive manufacturing for various advanced process.
2. Learn the concepts and the role of materials in material design and quality aspects
3. Understand the various types of simulation and mathematical models and their practical use
4. Utilize material handling equipment in manufacturing situations
5. Have wide knowledge on usage of additive manufacturing in various applications

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Determine the appropriate materials for manufacturing process for the product to be made.	L1
C02	Analyze the suitability of a manufacturing process to convert the raw material to designed specifications.	L4
C03	Developing the material ability and expertise to apply the latest	L5

	mathematical tools and techniques for computing and engineering practice.	
C04	Perform cost analysis for various manufacturing process to minimize the cost of processing the material.	L2
C05	Application of engineering and technological knowledge to solve a wide range of rapid manufacturing problems.	L3

COURSE CONTENT:	
MODULE 1: ROLE OF MATERIALS	09Hrs
Choosing Materials for Manufacturing, Multiple Materials, Metal AM Processes & Materials Composite Materials, Biomaterials, Heirarchical Materials & Bio mimetics, Ceramics & Bio-ceramics, Shape-Memory Materials, 4D Printing & Bio-active materials, Discussion on different materials used, multifunctional and graded materials in AM	
MODULE 2: MATERIAL DESIGN & QUALITY ASPECTS	09Hrs
Machines for Additive Manufacturing, Secondary Rapid Prototyping processes, Intellectual Property, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing. Design for AM (Build orientation, Topology optimization, Conformal cooling channels).	
	3
MODULE 3: MATHEMATICAL MODELS IN AM	09Hrs
Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation. Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Model validation for different criteria). Thermal cycle, Single bead and multi bead formation in cladding based AM processes	
MODULE 4: ADDITIVE MANUFACTURING FOR BIO-MEDICAL DEVICES & OTHERS	09Hrs
Bio microfluidics, Tissue Engineering. 3D Printing in Medicine, Computer Aided Design approach, medical research and clinical grade AM materials and AM fabrication methods,	

Biomedical Applications, Direct Digital Manufacturing, Distributed Manufacturing, Mass Customization, , Aerospace & Automotive Applications, Architectural Engineering, Food & Consumer Applications, Personalized Surgery, Art, Fashion, Jewelry, Toys & Other Applications	
MODULE 5: RAPID MANUFACTURING OBJECTS	06Hrs
RM of polymeric objects, Direct and indirect routes for RM of metallic & ceramic objects, Advancement in RM (Synergistic integration of hybrid processes and multiple technologies). Smart materials.	

TEXT BOOKS:

- . Ian Gibson, David Rosen, and Brent Stucker, “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing” Springer, New York, NY, 2015.
- . Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

REFERENCES:

4. Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007
5. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
6. Duc Pham, S.S. Dimov, “Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling”, Springer-Verlag London, 2001.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3514					
TITLE OF THE COURSE	AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Automotive Chassis and Transmission Systems course provides a comprehensive study of the essential components that form the backbone of vehicles: the chassis and transmission systems. Through a blend of theoretical concepts and practical insights, participants will delve into chassis layouts, frame construction, front axle design, steering systems, clutches, gearboxes, and automatic transmission systems. This course equips participants with the knowledge and skills required to understand, analyze, and design key elements of automotive systems.

COURSE OBJECTIVES:

The objectives of the course are to:

1. To learn the types of chassis and axles.
2. To study about the steering system and its methods.
3. To understand the suspension systems and its components.
4. To learn the functions of universal joint and propeller shafts.

COURSE OUTCOMES:

3

CO No.	Outcomes	Bloom's Taxonomy Level
C01	To make students familiar with the constructional details of chassis and body.	L2
C02	The student will understand the principle and working of the Torque Converters	L2
C03	The student will know about the Automatic Transmission and Applications of Automatic Transmission	L1
C04	The student will understand the principle and working of the Hydro-Static Drive and Electric Drives.	L2
C05	The student will understand the principle and working of the clutch, gearbox	L2

COURSE CONTENT:	
MODULE 1 Chassis & Body	08Hrs
Types of chassis layout with reference to power plant locations and drive. Vehicle frames. Various types of frames. Constructional details. Materials. Testing of vehicles frames., Loads acting on vehicle frame. Integrated body construction, BIW types and corresponding design parameters, Vehicle interior system, A, B, & C Pillar.	
MODULE 2 Front Axle And Steering System	08Hrs
Types of front axle. Construction details. Materials. Front wheel geometry viz. Castor, Camber, King pin inclination, Toe-in. Conditions for true rolling motion of wheels during steering. Steering geometry. Ackerman and Davis steering system. Constructional details of steering linkages. Different types of steering gear boxes. Steering linkages and layouts. Power assisted steering.	
MODULE 3 Clutch and Gear Box	10Hrs
Clutch – function – clutch actuating mechanism – Mechanical and hydraulic types – clutch material – single plate dry clutch – dual plate dry clutch – multi plate wet clutch – semi centrifugal and centrifugal clutch – motor cycle clutch – Diaphragm clutch – fluid coupling and torque converter – Trouble shooting of Clutch. Gear Box – purpose – resistance offered to the motion of the vehicle – air resistance – rolling resistance – Resistance offered to the motion of the vehicle – gradient resistance – tractive effort -gear ratio – types of gear boxes – sliding mesh – constant mesh -synchromesh device – epicyclic – over drive – under drive and transfer cases – 4 wheel drive – gear shifting mechanism – floor shifting and steering column shifting – Automatic Gear box (CVT) -Trouble shooting of gear box.	
MODULE 4 Automatic Transmission systems	08Hrs
Principle of working of epi-cyclic gear train - Construction and working principle of Ford-T model gear box - Wilson gear box- construction, working and derivation of gear ratios - Cotal electromagnetic transmission - Automatic over-drive - Hydraulic control system for automatic transmission. Chevrolet automatic transmission - Turbo glide transmission - Power glide transmission - Toyota “ECT-i” [Automatic transmission with intelligent electronic control systems] - Mercedes Benz automatic transmission - Hydraulic clutch actuation system for automatic transmission	

MODULE 5 Hydro-Static Drive and Electric Drives	08Hrs
Hydrostatic drive – principle, types, advantages, limitations - Comparison of hydrostatic drive with hydrodynamic drive - Construction and working of typical Janny hydrostatic drive. Lay-out of elective drive - Principle of early and modified ward Leonard control systems – advantages, limitations, performance characteristics	

TEXTBOOKS:

- 1 Tim Gilles, Automotive Chassis-Brakes, Steering and Suspension, Thomson Delmer Learning, 2005.
- 2 Heldt.P.M, “Automotive Chassis”, Chilton Co., New York, June 2012.

REFERENCES:

- 1 Jornsens Reimpell, Helmut Stoll, Automotive Chassis: Engineering Principles, Elsevier, 2nd edition, 2001.
- 2 Crouse.W.H, Automotive Chassis and Body, McGraw Hill New York, 1971.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3512					
TITLE OF THE COURSE	Electrical Machines and power Systems					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

COURSE OBJECTIVES :

Identify different types of electrical machines and their components.

Interpret simple power system diagrams and schematics.

Understand the operating principles of AC and DC machines and their differences.

Design simple electrical circuits using electrical machines

Describe the challenges and benefits of renewable energy integration.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Identify and differentiate various types of electrical machines and their components.	L1
CO2	understand the fundamental principles of transformers, including electromagnetic induction and mutual inductance, and the different types of transformers used in power systems.	L1
CO3	Utilize basic load flow analysis techniques to determine power distribution and voltage profiles in power systems.	L3
CO4	Differentiate between alternating current (AC) and direct current (DC) machines in terms of their energy conversion processes.	L3
CO5	Understand the importance of integrating renewable energy sources in reducing carbon emissions and promoting sustainability.	3 L3

COURSE CONTENT:

MODULE 1		7Hrs
Fundamentals of electrical and machine systems		
Definition and significance of electrical machines and power systems. Overview of the roles of generators, motors, transformers, and other components in power systems. Basic understanding of voltage, current, power, and energy in electrical systems.		
MODULE 2		8 Hrs
Transformers: Principles and application		
Faraday's law and electromagnetic induction as the basis for transformer operation.		
Types of transformers: power transformers, distribution transformers, autotransformers, etc.		
Components and construction of transformers, including core, windings, insulation, and cooling		

systems. Transformer efficiency, voltage regulation, and power factor considerations.	
MODULE 3	8 Hrs
AC and DC Machines: Working and Characteristics DC machines: generators and motors, electromagnetic induction, commutation, and back EMF. AC machines: induction motors and synchronous machines, rotating magnetic field, torque production. Components of DC and AC machines: armature, field windings, commutator, slip rings, rotor, stator, etc. Comparisons between AC and DC machines in terms of applications and advantages.	
MODULE 4	8 Hrs
Power system analysis and stability Load flow analysis: solving power system equations to determine power flows and voltage profiles. Power system stability: transient and steady-state stability, factors affecting stability. Reactive power control and voltage regulation in power systems. Importance of power system analysis for ensuring reliability and preventing blackouts.	
MODULE 5	8 Hrs
Renewable energy integration and future trends Challenges and solutions in integrating solar, wind, and other renewable energy sources. Micro grids and smart grids: concepts and benefits for decentralized power generation. Emerging technologies: superconducting machines, energy storage systems, and advanced control strategies. Future trends in electrical machines and power systems, including sustainability and grid modernization.	

TEXT BOOKS :

- . Stephen J. Chapman (2011). "Electric Machinery Fundamentals", McGraw – Hill Publishing Company Limited, New Delhi.
- . Mohamed E. El-Hawary (2008). "Introduction to Electric Power Systems". Wiley India Private Ltd., New Delhi.

REFERENCES :

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- . Ned Mohan (2012). "Electric Power Systems: A First Course", Wiley India Private Ltd., New Delhi.
- . John Grainger and William D. Stevenson Jr. (2011). "Power System Analysis" McGraw – Hill Publishing Company Limited, New Delhi.

SEMESTER	V					
YEAR	III					
COURSE CODE	21ME3515					
TITLE OF THE COURSE	Renewable Energy Sources					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The Renewable Energy Sources course provides a comprehensive exploration of various sustainable energy options that contribute to a cleaner and greener future. Through theoretical knowledge and practical applications, participants will delve into solar energy, wind energy, biomass, tidal energy, ocean thermal energy, hydropower, geothermal energy, and emerging sources like hydrogen. This course equips participants with a profound understanding of renewable energy technologies and their potential to reshape the global energy landscape

COURSE OBJECTIVES:

The objectives of the course are to:

1. To educate the students scientifically the new developments in renewable energy studies
2. To make understand the new developments in non-conventional and renewable energy studies.
3. To emphasize the significance of Green Energy Technologies

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To understand importance of solar energy applications	L1
CO2	To know the principles of power generation by wind energy	L2
CO3	To know ocean energy technologies to harness power	L2
CO4	To appreciate the use of hydrogen as renewable energy source	L3
CO5	Develop capability to do basic design of bio gas plant	L2

COURSE CONTENT:

MODULE 1 Solar Energy	10 Hrs
Solar Energy- Solar radiation its measurements and prediction - solar thermal collectors - flat plate collectors, concentrating collectors – applications - heating, cooling, desalination, drying, cooking, etc. Principle of photovoltaic conversion of solar energy - types of solar cells and fabrication -photovoltaic applications - battery charging, domestic lighting, street lighting.	
MODULE 2 Wind Energy	08 Hrs
Wind Energy- Wind energy - energy chains - application - historical background, merits and limitations - nature of wind - planetary and local day / night winds - wind energy quantum - power in wind- turbine efficiency - torque thrust calculations - velocity at different heights - site selection - components of wind energy conversion system (WECS).	
MODULE 3 Energy from Biomass	08 Hrs
Energy from biomass - biomass as renewable energy source - types of bio mass fuels - solid, liquid and gas - biomass conversion techniques- wet process, dry process photosynthesis - biogas generation - factors affecting bio- digestion - classification of bio gas plant - continuous, batch and fixed dome types - advantages and disadvantages	
MODULE 4 Tidal, Ocean Thermal Energy, Hydel and Geothermal Energy Conversion	08 Hrs
Tidal Energy: tide – spring tide, neap tide – tidal range – tidal power – types of tidal power plant – single and dual basin schemes – requirements in tidal power plant - ocean thermal energy conversion (OTEC): principle - open and closed OTEC cycles - ₄ hydel energy: micro hydro - geothermal energy: geothermal energy sources - power plant and environmental issues.	
MODULE 5 New Energy Sources	08 Hrs
Hydrogen as a renewable energy source - sources of hydrogen - fuel for vehicles - hydrogen production - direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production - storage of hydrogen - gaseous, cryogenic and metal hydride - fuel cell – principle of working, construction and applications	

TEXTBOOKS:

1. Rai.G.D, Non- conventional resources of energy, Khanna publishers, Fourth edition, 2010.
2. Khan. B.H, Non-Conventional Energy Resources, McGraw Hill, Second edition, 2009.

REFERENCES:

1. Rao.S & Parulekar, Energy Technology, Khanna publishers, Fourth edition, 2005.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3601					
TITLE OF THE COURSE	Machine Design Practice					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV		Mechanics of Solids

Summary:

This course covers mechanical power transmission systems like belt, rope, and chain drives, as well as spur, helical, bevel, and worm gears. Students will analyze stress, design for strength, and use FEA software for gear analysis. The course explores lubricants, bearing design, and practical experiments. Additionally, it focuses on clutch and brake design, considering self-locking and heat generation, with analysis using FEA software. Upon completion, students will possess the skills to optimize power transmission systems for diverse engineering applications.

COURSE OBJECTIVES:

The objectives of the course are:

- Learn Lewis equation and form factor to analyze stresses in gear teeth and design spur and helical gears for strength. Use of FEA software
- Understand the principles, advantages, and applications of belt, rope, and chain drives in various mechanical setups.
- Conduct a laboratory experiment on journal bearings to gain practical knowledge and experience.
- Design block and band brakes, considering self-locking aspects and heat generation, and analyze their behaviour using FEA software

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Design appropriate drive by analyzing load, speed, and distance parameters to optimize performance	L3
CO2	Assess the stresses in gear teeth and design for strength using the Lewis equation and form factor.	L3
CO3	Construct efficient worm gear drives by incorporating strength, dynamic, wear loads, and efficiency factors	L3
CO4	Analyze the properties of lubricants and their mechanisms in bearing systems.	L3
CO5	Evaluate the design features clutches and brakes.	L3

COURSE CONTENT:	
MODULE 1: Belt, Rope and Chain Drives	08 Hrs
Introduction to belt, rope, and chain drives: Understanding the principles, advantages, and applications of these power transmission systems in various mechanical setups. Design and selection of drives: Analyzing factors such as load, speed, and distance to determine appropriate belt, rope, and chain types for optimal performance.	
MODULE 2: Spur and Helical gears	09 Hrs
Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear load. Helical Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads. Analysis using FEA software.	
MODULE 3: Bevel and worm gears	09 Hrs
Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads. Worm Gears: Definitions, design based on strength, dynamic, wear loads and efficiency of worm gear drives. Analysis using FEA software.	
MODULE 4: Bearings	08 Hrs
Lubricants and their properties, mechanisms of lubrication bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, Heat dissipated, bearing materials, examples of journal bearing and thrust bearing design. Laboratory experiment on Journal bearing.	
MODULE 5: Clutches and Brakes	08 Hrs
4	
Design of clutches: Single plate, multi plate and cone clutches. Design of Brakes: Block and band brakes: Self-locking of brakes: Heat generation in brakes. Analysis using FEA software	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs
Static Stress analysis of gear tooth
Determination of a pressure distribution in a journal bearing.
Analysis of brake drum using FEA software

Text Books:

Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.

V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition, 2007.

Reference Books:

Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.

Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.

K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.

K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3602					
TITLE OF THE COURSE	Finite Element Analysis					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	inlar/Projects Hours	Total Hours	Credits
	3		2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1			
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COURSE OBJECTIVES :

- To help students to differentiate between finite difference and finite volume methods
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range two-dimensional real world structural and thermal problems
- To help students understand the use of higher order finite elements

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's taxonomy Level
CO1	Differentiate between finite difference and finite volume methods and their applications.	L3
CO2	Analyze a wide range two-dimensional field problems using finite element techniques	L2 4
CO3	Apply FE techniques to situations involving heat transfer by conduction	L3
CO4	Apply FE techniques in structural and solid mechanics	L3
CO5	Appreciate the use of higher order elements in FEM and apply the same	L3

COURSE CONTENT:	
MODULE 1	10Hrs

Introduction to computational methods, Finite difference method, Finite volume methods, Direct stiffness method, Integral formulation for numerical Solution – Variational method, Method of weighted residuals, Potential energy formulations; Principle of virtual work, Division of the region into elements - One dimensional linear element, Linear triangular element, Bilinear rectangular element, Representation for scalar and vector fields, Global, local and natural coordinate systems in one, two and three dimensions.	
MODULE 2	08Hrs
Governing differential equations; Integral equations for the element matrices, Triangular element matrix, Torsion of noncircular sections, General theory – Twisting of a square bar, Shear stress components, Evaluation of the twisting torque, Flow of an Ideal Fluid – Potential Formulation, Groundwater Flow, Flow Around a Cylinder, Other field problems, Derivative boundary conditions – 1D, Derivative boundary conditions – 2D,	
MODULE 3	08Hrs
Heat transfer by conduction, The one dimensional fin – 1, The one dimensional fin – 2, The composite walls, The two-dimensional fin, Boundary conditions, Long two-dimensional bodies – 1, Long two-dimensional bodies – 2, Axi-symmetric field problems, The differential equation – Axi-symmetric elements, Galerkin's method, Element matrices,	
MODULE 4	08Hrs
The axial force member - Element matrices, The truss element – Element matrices, Analysis of a pinned truss – 1, Analysis of a pinned truss – 2, A Beam element, Shape functions, Element matrices, Analysis of a statically indeterminate beam – 1, Analysis of a statically indeterminate beam – 2, A plane frame element – Element matrices, Two dimensional stress analysis - Stress, strain and Hooke's Law, The strain displacement equations, Two dimensional elasticity - Plane stress and plane strain, The displacement equations, The element matrices, Element stresses, Axi-symmetric stress analysis - Element matrices, Surface loads,	
MODULE 5	08Hrs
Iso-parametric elements in one and two dimensions, use of higher order elements, Element matrices, Introduction to Transient domain & Dynamic analysis, Changing the variables of integration- One-dimensional integrals, Two- dimensional integrals, Numerical Integration techniques- one-dimensional integrals, Quadrilateral regions, Triangular regions; Evaluating [B]; Evaluating the surface integrals, Pre and post processing, capability of commercially available FEM packages, Error analysis	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28

1.	Bars of constant cross section area, tapered cross section area and stepped bar
2.	Trusses (Minimum 2 exercises) Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc; (Minimum 6 exercises)
3.	Dynamic analysis) Fixed – fixed beam for natural frequency determination) Bar subjected to forcing function) Fixed – fixed beam subjected to forcing function
	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises)
4.	Stress analysis of a rectangular plate with a circular hole

TEXT BOOKS :

1. “Applied Finite Element Analysis”, L.J.Segerlind, John Wiley and Sons
2. “Applied Finite Element Analysis”, G.Ramamurthy, I.K.International Publishing House ,2009

REFERENCES :

1. “Concepts and Applications of Finite Element Analysis”, Cook, R. D., Malkus, D. S., Plesha, M. E., and Witt, R. J. Wiley Student Edition, Fourth Edition, First Reprint 2007.
2. “The Finite Element Method in Engineering”, Rao, S. S., Butterworth-Heinemann (An imprint of Elsevier), Published by Elsevier India Pvt. Ltd., 2007.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3603					
TITLE OF THE COURSE	CONTROL SYSTEMS ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	inlar/Projects Hours	Total Hours	Credits
	3	-	2	-	65	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- Gain a thorough understanding of the principles and theories behind control systems.
- Develop the ability to analyze control systems in both the time and frequency domains.
- Acquire skills to design and tune controllers to meet specific performance requirements.
- Master the state space analysis method for a better understanding of control system characteristics.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Apply fundamental control theory principles to model complex mechanical systems using transfer functions and state-space methods.	L3
C02	Implement time and frequency domain techniques to analyze the stability and performance of control systems.	L4
C03	Design and tune controllers, such as PID controllers and compensators, to enhance system performance and stability.	L3 5
C04	Apply root locus and frequency domain methods for the design and tuning of control systems.	L3
C05	Implement state space analysis to determine system controllability, observability, and stability.	L4
C06	Use computer software tools, such as MATLAB or Simulink, to simulate and analyze the behavior of control systems.	L3

COURSE CONTENT:	
MODULE 1	07Hrs
Introduction to Control Systems includes basics of control systems, differentiation between open loop and closed loop systems, system modeling using transfer functions and state space, along with block diagrams and signal flow graphs.	

MODULE 2	08Hrs
Time Domain Analysis introduces standard test signals, time response of first and second order systems, time domain specifications, steady-state errors, and stability analysis using the Routh-Hurwitz Criterion.	
MODULE 3	08Hrs
Frequency Domain Analysis consists of understanding the correlation between time and frequency response, usage of Bode and Nyquist plots, and stability analysis in the frequency domain through the Nyquist Criterion, gain and phase margins.	
MODULE 4	08Hrs
Design of Control Systems focuses on learning compensation techniques such as lead, lag, and lead-lag compensators, design of PID controllers, root locus technique, and frequency domain design with design specifications and performance indices.	
MODULE 5	08Hrs
State Space Analysis entails learning about the concept of state, state variables, state model, solutions to state equations, controllability, observability, pole placement design, and quadratic optimal control systems.	

Lab Component (26 hours):

Lab 1: Introduction to Control Systems - 4 hours

Software-based simulation to understand the basics of open and closed-loop control systems. Understanding transfer function and state-space representation of systems through modeling.

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Lab 2: Time Domain Analysis - 5 hours

Experimental study of the response of first and second-order systems for standard test signals. Implementing Routh-Hurwitz criterion to determine system stability.

Lab 3: Frequency Domain Analysis - 5 hours

Plotting and interpreting Bode and Nyquist plots. Applying Nyquist criterion to analyze system stability.

Lab 4: Design of Control Systems - 6 hours

Designing and tuning of a PID controller for a given system. Use of root locus method for system design.

Lab 5: State Space Analysis - 6 hours

Conducting state-space analysis for control systems. Observability and controllability analysis for given systems.

Textbooks:

- Nise, N. S., "Control Systems Engineering", 8th Edition, Wiley, 2019.
- Ogata, K., "Modern Control Engineering", 5th Edition, Prentice Hall, 2009.

References:

- Dorf, R. C., and Bishop, R. H., "Modern Control Systems", 13th Edition, Pearson, 2016.
- Franklin, G. F., Powell, J. D., and Emami-Naeini, A., "Feedback Control of Dynamic Systems", 8th Edition, Pearson, 2019.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3605					
TITLE OF THE COURSE	ROBOT KINEMATICS AND DYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES :
To introduce to the control position and orientation of the tool in the three dimensional space.
To make the student familiar with the joint variables and the position and the orientation of the tool.
To discuss about creating paths for the tool to follow in order to do useful tasks
To properly regulate the system's high-speed motion.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To control both the position and orientation of the tool in the three dimensional space.	L2
CO2	The relationship between the joint variables and the position and the orientation of the tool.	L2
CO3	Planning trajectories for the tool to follow on order to perform meaningful tasks.	L3
CO4	To precisely control the high speed motion of the system.	L3 ⁵
CO5		L3

COURSE CONTENT:	
MODULE 1-INTRODUCTION	10Hrs
Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.	
MODULE 2 DIRECT KINEMATICS	08Hrs

Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.	
MODULE 3 INVERSE KINEMATICS	08Hrs
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.	
MODULE 4 WORKSPACE ANALYSIS AND TRACJECTORY PLANNING	08Hrs
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space teclnique in trajectory planning.	
MODULE 5 MANIPULATOR DYNAMICS	08Hrs
Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange Euler formulation, problems.	

TEXT BOOKS :

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Me Graw Hill Publishing company Ltd., 1995.

REFERENCES :

1. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
2. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing hguse, 1993.
3. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, MIT Press, 2003.
4. John J. Craig, Introduction to Robotics Mechanics and Control, Third Edition, Pearson, 2008.
5. Bijay K. Ghosh, Ning Xi, T.J. Tam, Control in Robtics and Automation Sensor -Based integration, Academic Press, 1999.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3606					
TITLE OF THE COURSE	INDUSTRIAL AUTOMATION-I					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to
introduce the importance of automation techniques manufacturing and process industries.

impart the role of PLC in industry automation.

expose to various control techniques employed in process automation.

develop automation system for manufacturing and process industries.

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand the concept of Industrial automation	L2
C02	Illustrate the computer based industrial automation	L3
C03	Develop automation systems for manufacturing and process industries	L4
C04	Demonstrate the use of robotics in industrial automation	5 L2

COURSE CONTENT:

MODULE 1: Introduction to Industrial Automation		09Hrs
Automation -History of Automation, Reasons for automation, Disadvantages of automation, Automation systems, Types of automation – Fixed, Programmable and Flexible automation, Automation strategies Industrial Automation Systems: Components, classification and overview of manufacturing Systems, Flexible Manufacturing Systems (FMS), Types of FMS, Applications and benefits of FMS.		
MODULE 2: Computer based industrial automation		08Hrs
Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries		

includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation.	
MODULE 3: Programmable Logic Controller	08Hrs
Controllers and Actuators: Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.	
MODULE 4: : Distributed Control System	08Hrs
Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS)	
MODULE 5: Robots Technology & Artificial Intelligence	09Hrs
Robots Technology of the future: Robot Intelligence, Advanced Sensor capabilities, Telepresence and related technologies, Mechanical design features, Mobility, locomotion and navigation, the universal hand, system integration and networking. Artificial Intelligence: Goals of AI research, AI techniques – Knowledge representation, Problem representation and problem solving, LISP programming, AI and Robotics, LISP in the factory.	

TEXT BOOKS:

1. M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5 th Edition, Pearson Education, 2009.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.

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REFERENCES:

- Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson New International, 2013.
- Lukas M.P, " Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.

N. Viswanandham, Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", 1st Edition, 2009

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3607					
TITLE OF THE COURSE	COMPUTATIONAL TOOLS FOR ADDITIVE MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	48	3

COURSE OBJECTIVES:

- The primary objective of the course is to give students both a practical and a theoretical knowledge of every stage in the additive manufacturing.
- To provide a broad overview of both hardware and software for additive manufacturing
- To introduce to methods for parametric modeling of solid objects that take into account fabrication constraints.
- To cover optimization methods that are applied to automate the design process and additive manufacturing process.
- To cover latest research work in the field of computational fabrication

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy L⁵level
CO1	Students will be able to understand and use fundamental computer graphics in the context of design and additive manufacturing	L2
CO2	Students will be able to develop geometric models both parametric and organic using computational geometry techniques	L3
CO3	Students will be able to analyze many instances of recent computational fabrication systems that seamlessly blend parametric modeling, slicing and optimization	L3
CO4	In the second part of the semester, students work in groups on large open-ended projects	L1
CO5	Students will be introduced to case studies of latest research papers in the field of additive manufacturing	L2

COURSE CONTENT:

MODULE 1	08 Hrs
Object Transformations: Object Translation, Object Scaling, Object Rotation, Object Reflection, Object Scaling module	
MODULE 2 Geometric Modeling	08 Hrs
Hermite Curve Design, Hermite Surface Design, Bezier Curve Design, Bezier Surface Design, B-Spline Curve Design, B-Spline Surface Design, Parametric Design	
MODULE 3 Computational geometry	10 Hrs
Convex Hulls: Convexity, The Incremental Algorithm, Analysis of Algorithms, Gift Wrapping and Graham Scan, Lower Bound, Divide-and-Conquer; Polygons: Diagonals and Triangulations, Tetrahedralizations, Basic Combinatorics, The Art Gallery Theorem, Scissors Congruence in 2D, Scissors Congruence in 3D; Triangulations: Point Sets, Basic Constructions, Delaunay Triangulations; Voronoi Diagram	
MODULE 4 Optimization Methods	08 Hrs
Optimization methods for preprocessing and post processing analysis of geometric models for additive process friendly part builds	
MODULE 5	08 Hrs
Case Studies from latest research papers	

TEXTBOOKS:

1. Zeid, I. (1991). CAD/CAM theory and practice. McGraw-Hill Higher Education.

REFERENCES:

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1. Kieran, Stephen, and James Timberlake. Refabricating Architecture: How Manufacturing Methodologies are Poised to Transform Building Construction. New York, NY: McGraw-Hill, 2003. ISBN: 9780071433211.
2. Schodek, Daniel, et al. Digital Design and Manufacturing: CAD/CAM Applications in Architecture and Design. New York, NY: John Wiley & Sons, 2004. ISBN: 9780471456360.
3. Schwalbe, M., 2016. Predictive Theoretical and Computational Approaches for Additive Manufacturing: Proceedings of a Workshop.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3608					
TITLE OF THE COURSE	HEV / EV SYSTEM DESIGN ARCHITECTURE					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	0	0	-	42	3

COURSE OBJECTIVES:

The course will enable the students to:

- Explain the basics of electric and hybrid electric vehicles, their architecture
- Explain hybrid electric vehicle architecture, design and component sizing in hybrid electric vehicles.
- Analyze various electric drives suitable for hybrid electric vehicles
- Demonstrate different configurations of electric vehicles and its components.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals	L1
CO2	Analyse the use of different power electronics devices and electrical machines in hybrid electric vehicles	L3
CO3	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	5 L1
CO4	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis	L2
CO5	Understand Energy Management strategies in HEVs	L1

COURSE CONTENT:

MODULE 1 Design & Engineering – xEV	08 Hrs
xEV : micro to mild to PHEV to HEV to REEV to EV - Hybrid-Electric Vehicle Power trains - Vehicle , Energy Storage System (VESS) Design - Computational Systems Design (CSD) - Transportation Electrification	

MODULE 2 Introduction to Advanced Electric Vehicles	08 Hrs
Fundamentals of xEVs and key challenges and opportunities of AEV technologies - Engineering philosophy of various xEVs (HEV, PHEV and BEV, REEV)	
MODULE 3 Energy Storage Systems	08 Hrs
Energy storage systems used; Battery electro-chemistry, battery design and construction, charging and discharging, power density, Battery interface with motive source	
MODULE 4 Power Electronics for Electric Vehicles & Energy Conversion	08 Hrs
Power electronics including switching, AC-DC, AC-AC conversion, electronic devices and circuits used for control and distribution of electric power Electric Drives / Electromechanical Motors & motive power splitting concepts, and interface within power train system	
MODULE 5 Hybrid Electrical Vehicles	10 Hrs
Introduction - System Overview - Power train architecture - Parallel, Series and Combined - Types of xEVs - Vehicle layout and packaging options. - Energy devices & combinations - examples & Case Studies - Environmental Impact - Regulatory Issues (CO ₂ gas and particulate emissions) - Duty Cycles in Indian cities; performance (off cycle, durability) - Sustainability assessment; cradle to grave environmental impact.	

TEXTBOOKS:

1. Iqbal Husain, "Electric and Hybrid Vehicles –Design Fundamentals", CRC Press
2. Mehrdad Ehsani, Yimin Gao, Sebastian E.Gsay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell vehicles-Fundamentals - Theory and Design", CRC Press

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REFERENCES:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 2003
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3609					
TITLE OF THE COURSE	NOISE, VIBRATION AND HARSHNESS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	--	-	-	42	3

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES:

- To understand the fundamentals of sound and its measurement.
- Develop knowledge in finite element-based formulation for eigenvalue, frequency response, and transient dynamic problems
- Develop knowledge in modal and direct frequency response approaches used for the solution of vibration problems
- Learn applications of FEA and optimization to solve dynamic problems for vibration attenuation and noise reduction
- To know the most dominant sources of noise and vibration in cars, the dominant transmission paths including their relative importance at different driving conditions.
- To get an overview of state-of-the art in Computer Aided Engineering applied to NVH together with examples of NVH issues treated by CAE and to understand the limitations of the models used.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the fundamentals of sound and its measurement.	L2
CO2	Demonstrate of FEA tools solve dynamic problems for vibration.	L3
CO3	Execute forced harmonic and transient dynamic response studies by using dampening methods.	L2
CO4	Apply the knowledge ssources of vehicle vibration and vibration isolation techniques.	L3
CO5	Develop knowledge on advanced topics in finite element based NVH optimization	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Fundamentals of sound:	

Definition of NVH, Vehicle noise - Direct sound generation mechanism: airborne sound; Indirect sound generation mechanism: structure borne sound; Subjective response sound, Acoustic variables, basic attributes of sound such as wavelength, period, frequency; speed of sound, Decibel scale, Wave equation, types of sound fields, Measures of sound: Sound pressure, sound intensity and sound power, Combining sources: dB arithmetic, Standing wave, Beating, Impedance, Human hearing: frequency Versus sound pressure level, Loudness: phons and sones as noise descriptors; Weighting networks, Leq and various noise metrics for road noises.

MODULE 2	10Hrs

Finite element formulation for 1D and 2D eigenvalue problem
 Introduction to Hamilton's principle; Principle of minimum potential energy; stresses and equilibrium; strain displacement relationship; stress strain relationship ; special cases - 1D and 2D problems; natural coordinate system; element and global stiffness & mass matrix for 1D & 2D spring, truss, beam elements, 2D CST element, quadrilateral element; element and global stiffness & mass matrix for 1D & 2D spring, truss, beam elements, 2D CST element, quadrilateral element; harmonic loads- wheel unbalance, speed breakers, harmonic loads- wheel unbalance, speed brakers, and engine unbalance; real eigenvalue problem formulation; orthogonal properties of eigenvectors; Raleigh quotient; generalized mass, stiffness and force vector; consistent mass matrix and lump mass matrix; rigid body modes

MODULE 3	08Hrs

Damping & forced harmonic and transient dynamic response analyses
 Modal damping, Raleigh Damping, structural damping; mathematical modeling of elastomers with static and dynamic stiffness with frequency dependent characteristics;
 Mode superposition method and direct method for solution of forced harmonic and transient dynamic analyses; physical verses modal coordinates; modal mass, modal stiffness, & modal force; cut-off frequency for solution of low frequency NVH problems; Nyquist rule

MODULE 4	08Hrs

Sources of Vehicle vibration:
 Power train and Engine vibrations; driveline vibrations; chassis and suspension vibrations; Control strategies; Human response to vehicle vibrations, concept of harshness; subjective and objective evaluation of vehicle harshness. 6
Vibration Isolation and Control:
 Introduction; damping of vibrations; vibration isolation and absorption; design of a Vibration Absorbers, unconstrained and constrained layer damping treatment, add on dampers and stiffeners, Introduction to Active Vibration Control.

MODULE 5	08Hrs

Advanced topics in finite element based NVH optimization
 Modal alignment; point mobility analysis; transfer function analysis; vibroacoustic - applications of fluid-structure interaction to predict noise and vibration using finite element software; applications of topology and sizing optimization for automotive problems.

TEXT BOOKS:	
1.	Finite element analysis, P. Sheshu, PHI Learning Pvt. Ltd., New Delhi
2.	Kinsler, L.E., Frey, A.R., Coppens, A.B. and Sanders, J.V., 2000. Fundamentals of acoustics. John wiley & sons.

3.	Mathew Harrison Vehicle Refinement- Controlling Noise & Vibration in Road Vehicles, Elsevier Publication(2004).
4.	Introduction to optimal design, J.S. Arora, 4th edition, Elsevier Science Publishing Co. Inc

REFERENCES:	
1.	Theory and Problems of Mechanical Vibrations - William W. Seto, McGraw Hill International BookCo., Singapore (Schaum's outline series)
2.	Mechanical Vibrations - S. S. Rao, Pearson Education Inc.,
3.	Mechanical Vibrations - S. Graham Kelly, Schaum's Outline Series, Tata McGraw Hill Publishing Co.Ltd., New Delhi.
4	Finite element procedures, K.J. Bathe, Prentice-Hall

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3610					
TITLE OF THE COURSE	Experimental Methods for Mechanical Engineers					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

Summary:

The " Experimental Methods for Mechanical Engineers " course provides a comprehensive exploration of fundamental concepts and practical applications of experimental techniques within the field. Throughout the course's modules, students are exposed to a structured learning journey that equips them with the necessary skills and knowledge to proficiently plan, execute, analyze, and communicate experimental findings.

COURSE OBJECTIVES:

The objectives of the course are:

1. Understand and apply mechanical experimental methods effectively.
2. Proficiently use instruments for accurate data collection and analysis.
3. Design experiments, analyze data, optimize outcomes through statistical methods.
4. Integrate advanced techniques, simulations for comprehensive problem-solving.
5. Communicate findings ethically and clearly through reports and presentations.

6

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Compare and contrast different experimental design methods and their applications.	L3
CO2	Critically assess experimental designs and propose modifications for enhanced outcomes	L2
CO3	apply statistical tools, such as mean, standard deviation, and hypothesis testing, to analyze experimental data critically	L3
CO4	Synthesize experimental data, simulations, and literature to propose innovative solutions.	L3
CO5	Develop effective communication of experimental procedures and outcomes in written reports.	L3

COURSE CONTENT:	
MODULE 1 Introduction to Experimental Methods	08 hours
Introduction to the significance of experimental methods in mechanical engineering. Steps in the experimental process: formulation, design, execution, analysis, and conclusion. Role of uncertainty and error analysis. Ethics and safety considerations in conducting experiments. Overview of measurement systems, instruments, and sensors used in experiments.	
MODULE 2 Measurement Techniques and Instrumentation	10 hours
Principles of measurement: accuracy, precision, resolution, range. Selection and use of instruments: thermocouples, strain gauges, pressure transducers, accelerometers. Data acquisition systems and signal conditioning. Calibration procedures and techniques for ensuring measurement accuracy.	
MODULE 3 Design of Experiments and Statistical Analysis	08 hours
Factors affecting experimental design: objectives, variables, constraints, interactions. Full factorial, fractional factorial, and Taguchi methods for experimental design. Statistical analysis: mean, standard deviation, confidence intervals, hypothesis testing, regression analysis. Case studies illustrating the application of experimental design and statistical analysis.	
MODULE 4 Data Analysis and Interpretation	08 hours
Techniques for data reduction, visualization, and graphical representation. Error analysis and propagation of uncertainties in experimental measurements. Curve fitting and analysis of experimental data using software tools. Introduction to response surface methodology and optimization techniques. Case studies involving data analysis and interpretation of experimental results.	
MODULE 5 Advanced Experimental Techniques and Applications	08 hours
Exploration of advanced techniques: non-destructive testing, image analysis, acoustic measurements. Integration of computational simulations with experimental data. Real-world case studies showcasing experimental methods in mechanical engineering applications. Importance of effective communication: report writing, documentation, and presentation of experimental findings.	

TEXTBOOKS:

1. J.P. Holman, Experimental Methods for Engineers, McGraw-Hill Education, 2017.
2. Anthony Wheeler, Ahmad Ganji, Introduction to Engineering Experimentation, Pearson, 2010

REFERENCES:

1. C. Suryanarayana, Experimental Techniques in Materials and Mechanics, CRC Press, 2011
2. A. W. Hendry, Elements of Experimental Stress Analysis t, Elsevier Science, 2013.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3611					
TITLE OF THE COURSE	Rapid tooling and industrial Applications					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES :

- Identify different rapid tooling methods and their underlying principles
- Summarize the steps involved in various rapid tooling processes
- Illustrate how rapid tooling fits into the broader context of agile manufacturing strategies.
- Analyse the potential challenges and risks associated with implementing rapid tooling in a manufacturing setting.
- Compare and contrast the cost-effectiveness and efficiency of rapid tooling methods for different types of products.

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COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Describe the specific product types for which each rapid tooling method is suitable	L1
CO2	Describe how the various steps in rapid tooling processes contribute to the overall efficiency and accuracy.	L2
CO3	List the key characteristics that define an agile manufacturing approach..	L3

CO4	Demonstrate the ability to identify specific manufacturing scenarios where rapid tooling may face obstacles.	L3
CO5	Describe the variables that influence the selection of a specific rapid tooling method for a given product.	L2

COURSE CONTENT:		
MODULE 1		6Hrs
Introduction to Rapid Tooling and its Principles Rapid tooling and its significance in modern manufacturing. Injection moulding, CNC machining, 3D printing, etc. Principles underlying each method: Material selection, tool design, process parameters.		
MODULE 2		8 Hrs
Steps Involved in Rapid Tooling Processes Prototyping, tool fabrication, production. Sequential steps and their significance: Design, material selection, mould fabrication, testing. Mapping steps for specific rapid tooling methods.		
MODULE 3		6 Hrs
Agile Manufacturing and Integration of Rapid Tooling Agile manufacturing and its core principles. Explain the significance of agility in responding to market demands. Briefly discuss how agile manufacturing enhances competitiveness. Flexibility, adaptability, customer-centricity. Agile manufacturing in different industries. Rapid tooling aligns with agile manufacturing principles. Emerging trends and technologies in rapid tooling for agile manufacturing.		
MODULE 4		6 Hrs
Challenges and Risks in Rapid Tooling Implementation Importance of identifying and mitigating challenges. Technical challenges in rapid tooling issues related to tooling design complexities and precision. Implementation material selection impacts		

tool durability and quality. Economic challenges associated with rapid tooling. Present strategies for mitigating challenges and risks in rapid tooling. Role of research, planning, and process optimization. Emerging technologies and trends that may impact rapid tooling's challenges and solutions.	
MODULE 5	6 Hrs
Cost-Effectiveness and Efficiency in Rapid Tooling Methods Cost-effectiveness and efficiency in the context of rapid tooling. Significance of evaluating these factors in manufacturing. Role of rapid tooling in streamlining production processes. Key factors influencing the cost-effectiveness of rapid tooling. Initial investment costs, material expenses, and production volume. Relationship between costs and return on investment (ROI).	

TEXT BOOKS :

5. Frank W. Liou (2007). "Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development", CRC Press
6. Chua Chee Kai, Leong Kah Fai, Lim Chu Sing (2003). "Rapid Prototyping: Principles and Applications". World scientific publishing company

REFERENCES :

7. R K jain. "Tool Engineering and design: A Practical Approach", allied publishers, Mumbai.
8. G. R. Nagpal "Tool Engineering" (2009) Khanna publishing house, New Delhi.

SEMESTER	VI					
YEAR	III					
COURSE CODE	21ME3612					
TITLE OF THE COURSE	FUNDAMENTALS OF DRIVES AND DC MACHINE MODELLING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	--	-	-	42	3

Prerequisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES:

- Comprehend Drive Systems Fundamentals.
- Analyze DC Machine Operation.
- Explore Drive Control Strategies.
- Model and Simulate DC Machines.
- Examine Drive System Components.
- Apply Knowledge in Practical Scenarios.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the foundational concepts of drive systems, including power electronics and motor control principles.	L2
CO2	Analyze the operation and behavior of DC machines in various load conditions.	L3
CO3	Apply different control strategies to electric drives for achieving desired performance characteristics.	L2
CO4	Model and simulate DC machines to predict and analyze their behavior under different operating conditions.	L3
CO5	Evaluate the interaction and function of drive system components, such as power converters and sensors, in achieving efficient operation.	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Module 1: Introduction to Electric Drives and DC Machines Introduction to electric drives, highlighting their significance in various industries. Additionally, it covers the fundamental aspects of DC machines, encompassing their diverse types, construction, and characteristic behaviors.	
MODULE 2	10Hrs

Power Electronics and Control Strategies Principles of power electronics as applied in electric drive systems. This is followed by an exploration of control strategies that are pivotal in governing the behavior of these drives. The module provides insights into both open-loop and closed-loop control techniques, illustrating their role in enhancing system performance.	
MODULE 3	08Hrs
Modeling and Analysis of DC Machines Mathematical modeling of DC machines, enabling students to understand the intricacies of their operations. It further delves into the analysis of DC machine behavior across a spectrum of load conditions, facilitating a comprehensive comprehension of their characteristics.	
MODULE 4	08Hrs
Control Techniques and Drive Components Control techniques employed within electric drives. Moreover, it critically examines the integral components of drive systems, including converters, sensors, and feedback devices. This exploration sheds light on their individual roles and collective contributions to the drives overall efficiency and functionality.	
MODULE 5	08Hrs
Simulation and Practical Applications Simulation techniques that predict DC machine behavior. Real-world application of control strategies, emphasizing their role in achieving specific performance objectives.	

Textbook for Fundamentals of Drives:

"Power Electronics and Variable Frequency Drives: Technology and Applications" by Bimal K. Bose

"Electric Machinery and Transformers" by Bhag S. Guru, Huseyin R. Hiziroglu

Reference books:

"Electric Machinery Fundamentals" by Stephen J. Chapman

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"Power Electronics: Converters, Applications, and Design" by Ned Mohan, Tore M. Undeland, William P. Robbins

Open Electives:

SEMESTER	VI					
YEAR	III					
COURSE CODE	21OE0017					
TITLE OF THE COURSE	ROBOTICS ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To introduce the basic concepts, parts and types of robots.
- To make the student familiar with the various sensors, drive systems in robots and programming.
- To discuss about the various applications, justification and implementation of robot.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic principles of Robotic technology, configurations, control and programming of Robots	L2
C02	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
C03	To choose the appropriate Sensor and Machine vision system for a given application	L3 7
C04	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
C05	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material	

transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	08Hrs
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	08Hrs
Drive system, control system, robot drive mechanisms, hydraulic - electric - servomotor- stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	08Hrs
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	08Hrs
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS :

1. AshitavaGhosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES :

1. Fu, K. S, Gonzalez, R. C, Lee, C.S.G, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987
2. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	VI					
YEAR	III					
COURSE CODE	21OE0018					
TITLE OF THE COURSE	PRODUCT DESIGN AND MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To expose the students the basics of product design and manufacturing.
- To introduce students to the basic principles and evaluation methods of various aspects of designing components.
- To teach students about the Industrial manufacturability requirements.
- To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Analyse the product life cycle phases of any product and suggest appropriate strategies	L2
C02	Construct product planning and specification documents	L3
C03	Demonstrate the knowledge of Architectural and Industrial design aspects of product design	L3
C04	Apply design for excellence (DF-X) concepts in product design	L37
C05	Choose an appropriate manufacturing process for product prototyping.	L4

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry -Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies	

MODULE 2	08Hrs
Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD) Product Specifications: specifications established, establishing target specifications, setting the final specifications, Case Studies	
MODULE 3	08Hrs
Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies	
MODULE 4	08Hrs
Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies	
MODULE 5	08Hrs
Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereolithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies.	

TEXT BOOKS :

1. A C Chitale and R C Gupta, Product Design and Manufacturing -, PH1, - 3rd Edition, 2003

REFERENCES :

1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development - McGraw Hill -2000.
2. Tim Jones, Butterworth Heinmann, New Product Development - Oxford. UCI - 1997
3. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002
3. .L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	V					
YEAR	III					
COURSE CODE	21OE0015					
TITLE OF THE COURSE	AUTOMOBILE ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To understand basics of Automobile Engineering & various automotive system.
- To understand vehicle layout, vehicle specifications & important of automobile.
- To make the student conversant with drive train & transmission.
- Understand the various Automobile Electrical System, Vehicle performance & their safety

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain components of automotive vehicle	L1
C02	Describe functioning of automotive transmission system	L1
C03	Calculate the resistance offered to the automobile by various factors	L2
C04	Describe various electrical components used in automobiles	L1 7
C05	Diagnosis the faults of automobile vehicles.	L2

COURSE CONTENT:	
MODULE 1	08Hrs s
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	

MODULE 1	08Hrs
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	
MODULE 2	08Hrs
Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission, Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive.	
MODULE 3	10Hrs
Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. Suspension: Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), damping and shock absorbers Brakes: Types of brake systems - drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.	
MODULE 4	08Hrs
Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise.	
MODULE 5	08Hrs
Batteries: Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods. Lighting System & Accessories: Insulated & earth return systems, positive & negative earth systems, electrical fuel pump, speedometer, fuel, oil & temperature gauges, horn, wiper system, trafficator, sensors and actuators, electronic control unit, traction control devices. Vehicle maintenance Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system.	

TEXT BOOKS :

1. William H. Crouse., "Automotive Mechanics", Tata McGraw Hill Publishing House.

REFERENCES :

1. K. Newton and W. Seeds, T.K. Garrett, "Motor Vehicle", 13th Edition, Elsevier publications
2. Hans Hermann Braess, Ulrich Seiffen, "Handbook of Automotive Engineering ", SAE Publications

SEMESTER	V					
YEAR	III					
COURSE CODE	21OE0016					
TITLE OF THE COURSE	RAPID MANUFACTURING TECHNOLOGIES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To provide knowledge of methods for the manufacturing of prototypes from computer based models
- To understand the entire process of direct manufacturing from the creation of computer based models to their physical realization
- To understand the various methods of manufacturing and their merits, demerits and applications
- To impart students to convert CAD models into real life engineering components

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the various rapid prototyping technologies ,	L1
C02	Select appropriate technology for product development	L2
C03	Describe rapid prototyping techniques	L1 7
C04	Analyse the quality of a product using rapid prototyping technique	L3
C05	Describe application of rapid prototyping	L1

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction- Need for the compression in product development, Historical development, Fundamentals of RP, Advantages and Classification of RP systems. Process chain, RP Data	

Formats, Information flow in an RP system.	
MODULE 2	10Hrs
Stereo lithography Apparatus (SLA): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Solid ground curing (SGC): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications.	
MODULE 3	10Hrs
Fused Deposition Modelling (FDM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Laminated Object Manufacturing (LOM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Ballistic Particle Manufacturing (BPM): Principle.	
MODULE 4	10Hrs
Selective laser sintering (SLS): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Three dimensional Printing (3DP): Principle, process parameters, process details, machine details, products, Advantages, Limitations, applications. Laser Engineering Net Shaping (LENS) -Principle. Concept modellers like thermal jet printers, Sander's model maker, GenisysXs 3D printers, JP system 5, Object Quadra system.	
MODULE 5	10Hrs
Introduction to rapid tooling: Direct soft tooling- casting molds, Direct AIM, composite tooling. Indirect soft tooling- spray metal molding, silicon rubber molds, Castable resin and ceramic molds. Direct hard tooling-rapid tool, Laminated metal tooling, DMLS tooling. Indirect hard tooling- 3D keltool, ED electrodes, Ecotool, copy milling. Applications: Application-Material Relationship, Applications in Design, Applications in Engineering, Analysis and Planning. Application of Rapid prototyping in biomedical, automotive, aerospace, jewellery and coin industries.	

TEXT BOOKS :

1. C. K.Chua, K. F.Leong and C. S.Lim, Rapid prototyping: Principles and applications, World Scientific Publishers, 2003

REFERENCES :

1. Andreas Gebhardt, Hanser , Rapid prototyping, Gardener Publications, 2003.
2. L.W.Liou, F.W. Liou, Rapid Prototyping and Engineering applications: A tool box for prototype development,

DAYANANDA SAGAR UNIVERSITY

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SCHOOL OF ENGINEERING



**SCHEME & SYLLABUS
FOR
BACHELOR OF TECHNOLOGY (B.Tech.) – 2020**

MECHANICAL ENGINEERING

**(ME)
(upto 8th Semester)
(WITH EFFECT FROM 2020-21)**

SCHEME - B.TECH – 2020-21 ONWARDS**III SEM - MECHANICAL ENGINEERING**

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/ P	C	SEM	COURSE CODE
1	105	20ME2301	COMPLEX VARIABLES AND NUMERICAL METHODS	CR	03	01	--	--	04	*	***
2	105	20ME2302	ENGINEERING MATERIALS	CR	03	--	02	--	04	*	***
3	105	20ME2303	ENGINEERING MECHANICS	CR	03	--	--	--	03	*	***
4	105	20ME2304	THERMODYNAMICS	CR	03	--	--	--	03	*	***
5	105	20ME2305	COMPUTER AIDED MACHINE DRAWING	CR	02	--	04	---	04	*	***
6	105	20ME2306	MECHANICAL MEASUREMENTS	CR	03	--	02	--	04	*	***
7	105	20ME2307	SPECIAL TOPICS – I	CR	01	--	02	--	02	*	***
					18	01	10	-	24		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits

SCHEME - B.TECH – 2020-21 ONWARDS**IV SEM - MECHANICAL ENGINEERING**

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME2401	APPLIED THERMODYNAMICS	CR	02	01	02	--	04	*	***
2	105	20ME2402	MECHANICS OF MATERIALS	CR	02	01	--	--	03	*	***
3	105	20ME2403	FLUID MECHANICS AND MACHINES	CR	03	--	02	--	04	*	***
4	105	20ME2404	MANUFACTURING PROCESS	CR	03	--	02	--	04	*	***
5	105	20ENC001	ECONOMICS FOR ENGINEERS	CR	02	--	--	--	02	*	***
6	105	20ME2405	SPECIAL TOPICS – II	CR	01	--	02	--	02	*	***
					13	02	08	--	19		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits

SCHEME - B.TECH – 2020-21 ONWARDS

V SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME3501	HEAT TRANSFER	CR	03	--	02	--	04	III	20ME2304
2	105	20ME3502	KINEMATICS & THEORY OF MACHINES	CR	03	01	--	--	04	*	***
3	105	20ME3503	DESIGN OF MACHIN ELEMENTS – I	CR	02	01	02	--	04	IV	20ME2302
4	105	20ME3504	MANUFACTURING TECHNOLOGY	CR	03	--	02	--	04	*	***
5	105	20ME35XX	PROFESSIONAL ELECTIVE – I	CR	03	--	--	--	03	*	***
6	105	20OEXXX	OPEN ELECTIVE – I	CR	03	--	--	--	03	*	***
7	105	20ME3505	SPECIAL TOPICS – III	CR	02	--	--	--	02	*	***
					19	02	06	--	24		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – I			
SL.NO	COURSE CODE	COURSE TITLE	Group
1	20ME3506	INTRODUCTION TO ROBOTICS AND AUTOMATION	ROBOTICS & AUTOMATION
2	20ME3507	FUNDAMENTALS TO MACHINE LEARNING & ARTIFICIAL INTELLIGENCE	
3	20ME3508	ADDITIVE MANUFACTURING TECHNOLOGY	ADDITIVE MANUFACTURING
4	20ME3509	AUTOMATED MANUFACTURING SYSTEMS	
5	20ME3510	INTRODUCTION TO HYBRID & ELECTRIC VEHICLES	HYBRID & ELECTRIC VEHICLES
6	20ME3511	AUTOTRONICS	
7	20ME3512	REFRIGERATION AND AIR CONDITIONING	GENERAL
8	20ME3513	TOOL DESIGN	

SCHEME - B.TECH – 2020-21 ONWARDS

VI

SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME3601	DESIGN OF MACHINE ELEMENTS – II	CR	02	01	02	--	04	IV	20ME2402
2	105	20ME3602	FINITE ELEMENT METHODS	CR	02	01	02	--	04	*	***
3	105	20ME3603	MECHANICAL VIBRATIONS	CR	03	--	02	--	04	*	***
4	105	20ME36XX	PROFESSIONAL ELECTIVE – II	CR	03	--	--	--	03	*	***
5	105	20ME36XX	PROFESSIONAL ELECTIVE – III	CR	03	--	--	--	03	*	***
6	105	20OEXXX	OPEN ELECTIVE – II	CR	03	--	--	--	03	*	***
7	105	20ENC002	LAW FOR ENGINEERS	CR	02	--	-	--	02	*	***
					18	02	06	--	23		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE - II			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME3604	DRIVES & CONTROL SYSTEMS	ROBOTICS & AUTOMATION
2	20ME3605	ELECTRICAL MACHINES AND POWER SYSTEMS	
3	20ME3606	MATERIALS FOR AM	ADDITIVE MANUFACTURING
4	20ME3607	PROCESSING OF PLASTICS & COMPOSITES	
5	20ME3608	AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS	HYBRID & ELECTRIC VEHICLES
6	20ME3609	MODEL-BASED EMBEDDED CONTROL SYSTEM DESIGN	
7	20ME3610	RENEWABLE ENERGY SOURCES	GENERAL
8	20ME3611	PRODUCT DESIGN AND MANUFACTURING	

PROGRAM ELECTIVE - III			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME36112	ROBOT KINEMATICS AND DYNAMICS	ROBOTICS & AUTOMATION
2	20ME36113	INDUSTRIAL AUTOMATION-I	
3	20ME36114	COMPUTATIONAL TOOLS FOR AM	ADDITIVE MANUFACTURING
4	20ME36115	MICRO AND NANO FABRICATION TECHNOLOGIES	
5	20ME36116	HEV / EV SYSTEM DESIGN ARCHITECTURE	HYBRID & ELECTRIC VEHICLES
6	20ME36117	MATERIALS AND MANUFACTURING PROCESSES FOR AUTOMOTIVE SYSTEMS	
7	20ME36118	INTERNAL COMBUSTION ENGINES	GENERAL
8	20ME36119	MEMS (MICRO ELECTRO MECHANICAL SYSTEMS)	

SCHEME - B.TECH – 2020-21 ONWARDS**VII****SEM - MECHANICAL ENGINEERING**

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME4701	CONTROL SYSTEMS ENGINEERING	CR	03	--	02	--	04	*	***
2	105	20ME47XX	PROFESSIONAL ELECTIVE – IV	CR	03	--	--	--	03	*	***
3	105	20ME47XX	PROFESSIONAL ELECTIVE – V	CR	03	--	--	--	03	*	***
4	105	20OEXXX	OPEN ELECTIVE – III	CR	03	--	--	--	03	*	***
5	105	20ME4702	MAJOR PROJECT PHASE – I	CR	--	--	--	04	02	*	***
					12	-	02	04	15		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – IV			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME4703	INDUSTRIAL AUTOMATION-II	ROBOTICS & AUTOMATION
2	20ME4704	AUTOMATION SYSTEM DESIGN	
3	20ME4705	INDUSTRY 4.0 AND IOT	ADDITIVE MANUFACTURING
4	20ME4706	CAD/CAM FOR AM	
5	20ME4707	VEHICLE DYNAMICS ADVANCED POWERTRAIN	HYBRID & ELECTRIC VEHICLES
6	20ME4708	ADVANCED ENERGY STORAGE	
7	20ME4709	COMPUTATIONAL FLUID DYNAMICS	GENERAL
8	20ME4710	OPERATIONS MANAGEMENT	

PROGRAM ELECTIVE – V			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME4711	ROBOT VISION SYSTEMS	ROBOTICS & AUTOMATION
2	20ME4712	ROBOT PROGRAMMING	
3	20ME4713	INTELLIGENT MANUFACTURING SYSTEMS	ADDITIVE MANUFACTURING
4	20ME4714	POWDER METALLURGY MANUFACTURING	
5	20ME4715	POWERTRAIN INTEGRATION IN HEV	HYBRID & ELECTRIC VEHICLES
6	20ME4716	ENERGY MANAGEMENT AND CONTROL STRATEGIES	
7	20ME4717	AUTOMOBILE ENGINEERING	GENERAL
8	20ME4718	TRIBOLOGY AND BEARING DESIGN	

SCHEME - B.TECH – 2020-21 ONWARDS

VIII

SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME48XX	PROFESSIONAL ELECTIVE – VI	CR	03	--	--	--	03	*	***
2	105	20ME4801	MAJOR PROJECT PHASE– II	CR	--	--	--	20	10	*	***
					03	-	-	10	13		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – VI			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME4802	ADVANCED AI FOR ROBOTICS	ROBOTICS & AUTOMATION
2	20ME4803	ROBOT SIMULATION & OFFLINE PROGRAMMING	
3	20ME4804	ADDITIVE MANUFACTURING FOR MEDICAL APPLICATIONS	ADDITIVE MANUFACTURING
4	20ME4805	SUSTAINABLE MANUFACTURING	
5	20ME4806	ADVANCED PROPULSION SYSTEMS FOR HYBRID ELECTRIC DRIVE VEHICLES	HYBRID & ELECTRIC VEHICLES
6	20ME4807	AUTOMOTIVE ELECTRONICS FOR EV'S	
7	20ME4808	FEM- STRUCTURAL MECHANICS APPLICATIONS	GENERAL
8	20ME4809	ORGANIZATIONAL BEHAVIOUR AND PROFESSIONAL COMMUNICATION	

III SEM - MECHANICAL ENGINEERING

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2301					
TITLE OF THE COURSE	COMPLEX VARIABLES AND NUMERICAL METHODS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	56	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	I	-	
2	II		

COURSE OBJECTIVES:

- Understanding basic concepts of Complex variables and Complex integration
- To illustrate its importance through applications to science and Engineering.
- To provide suitable and effective methods called Numerical Methods, for obtaining approximate representative numerical results of the problems.
- Understanding basic concepts of ODE and PDE to illustrate its power and utility through applications to science and Engineering.
- Understanding basic concepts of Probability and Random variables.
- Apply the concepts of Probability distribution in engineering.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyse Complex variables and complex integration	L2
CO2	Study the discrete and continuous random variables	L1
CO3	Analyse various distributions related to discrete and continuous random variables	L3
CO4	Analyse numerically the solution for ODEs	L3
CO5	Analyse numerically the solution for PDEs	L3
CO6	Apply knowledge or Mathematics in Science and Engineering.	L3

COURSE CONTENT:

MODULE 1	10Hrs
COMPLEX VARIABLES Complex function, Limits, Continuity, differentiability, Analytic Functions, CRequations, and Properties of Analytic functions.	

Self-Learning Component : Complex number and its properties	
MODULE 2	12Hrs
INTEGRATION IN THE COMPLEX PLANE Complex Integrals, Cauchy -Goursat Theorem, Independence of Path, Cauchy's Integral Formulas and Their Consequences, Cauchy's Two Integral Formulas, Some Consequences of the Integral Formulas, Applications. Self-Learning Component : Integration and some basic formulae	
MODULE 3	12Hrs
PROBABILITY THEORY Random Variable-Discrete and continuous random variables- Distribution and density function-Properties-Binomial Distribution-Poisson Distribution-Uniform Distribution-Gaussian Distribution-Exponential Distribution-Rayleigh Distribution-Conditional Distribution- Multinomial Distribution Density function-Properties Self-Learning Component : Events, Sample space	
MODULE 4	12Hrs
NUMERICAL METHODS FOR ORDINARY DIFFERENTIAL EQUATIONS Introduction to Numerical methods, Initial and Boundary value problems, Numerical solution of ODE, Picard's method, Taylor's series method, Euler's method, Modified Euler's method, Runge-Kutta method Self-Learning Component : First order ODE and its solving techniques	
MODULE 5	10Hrs
NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS Introduction of PDE, Classification of PDE: parabolic, elliptic and hyperbolic. Boundary and initial conditions, Taylor series expansion, analysis of truncation error, Finite difference method: FD, BD & CD, Higher order approximation, Order of Approximation, Polynomial fitting, One-sided approximation.	

TEXT BOOKS:

1. A First course in complex analysis with applications, Dennis Zill and Patrick Shanahan, Jones and Bartlett publishers.
2. A First Course in Probability, S. Ross, Pearson International Edition, 9th Edition
3. Fundamentals of Mathematical Statistics, S. C. Gupta and V. K. Kapoor, Sultan Chand & Sons, 11th Edition
4. Numerical Methods for Engineers, Chapra and Canale, Mc Graw Hill Education, 7th edition

REFERENCES:

1. Complex Variables and applications, Brown and Churchill, Mc Graw Hill Education, Eighth Edition.
2. Probability, Statistics and Statistics with Reliability, Queuing, and Computer Science Applications, Kishore Trivedi, Prentice Hall, 2nd Edition
3. Probability and Random Processes, S. Miller and Childers, Elsevier Inc., Second Edition
4. Advanced Engineering Mathematics, E. Kreyszig, Wiley, 10th Edition
5. A First Course in Numerical Methods, Ascher and Grief, SIAM 2011

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2302					
TITLE OF THE COURSE	ENGINEERING MATERIALS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

Perquisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course
1			

COURSE OBJECTIVES:

The objectives of the Course are to

- Describe the difference in atomic/molecular structure between crystalline and non-crystalline materials.
- Describe the tensile, compression, shear and bending deformations of the metalspecimen and to describe the changes in specimen profile up to the point of fracture.
- Determine the various phases present, composition and the mass fractions of thephases from a binary phase diagram.
- Name different kinds of steels, cast irons and non-ferrous alloys, and for each cite distinctive properties and typical uses.
- Understand the types and applications of ceramics and polymers.
- Learn the different manufacturing processes for composite materials.
- Familiarize with the testing standards for mechanical characterization

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Classify engineering materials based on their crystalstructure	L2
CO2	Calculate the material properties through testing of materials	L3
CO3	Interpret phase diagram for alloy preparation	L2
CO4	Relate the phase diagram, microstructure and themechanical properties of materials	L3
CO5	Select material for an application by analysing therequirements with the material properties	L1
CO 6	Prepare polymer composites by hand lay-up, vacuumagging, resin transfer moulding and filament winding processes	L3

COURSE CONTENT:

MODULE 1	8Hrs

Introduction to materials, Overview of Crystal Structure, Solid Solutions, Hume Rothery Rules, Crystal Imperfections, Critical nucleus size and Critical Free energy, Mechanism of Crystallization, Nucleation, Nucleation- Growth, Single crystal, Polycrystalline Materials, Basic principles of solidification of metals and alloys. Solidification time, Cooling curves, Non- crystalline solids.

MODULE 2	8Hrs

Testing of materials under tension, compression and shear loads, Hardness tests, fatigue and creep test. Impact testing, Fatigue testing, Fracture, Types, Fracture mechanics. Characteristics of creep curve & steady state creep. Fracture toughness & fatigue, Stress and temperature effects.

MODULE 3	10Hrs

Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Phase Rule, Unary System, Binary Phase diagrams, Iron-carbon system. Phase transformations. Transformation rate effects and Isothermal transformations (TTT Curves), Continuous cooling transformations, Microstructure and property changes in iron- carbon system, Iron-carbon equilibrium diagram, Heat treatments.

MODULE 4	8Hrs

Classification of steels and cast iron, Microstructure, Effect of alloying elements on steel, Ferrous alloys and their applications, High Resistivity and High temperature alloys, Selection of material for various applications- case studies.

MODULE 5	8Hrs

Ceramics, Glass Ceramics, Advanced ceramics, Functional properties and applications of ceramic materials and Glasses, Polymers, Composites, Nanomaterials, Materials used in additive manufacturing.

List of Laboratory/Practical Experiments activities to be conducted : 28Hrs

1. Tension Test- To understand the tensile characteristics of mild steel through tensile testing and thereby determine mechanical properties such as ultimate tensile strength, elastic modulus, proportionality limit, yield point, fracture stress, percentage elongation & reduction in area.
2. Compression Test- To determine the compressive strength of aluminium and cast-iron specimens and to identify the failure modes of ductile/brittle materials through evaluation of their failure modes of above material.
3. Shear Test - To determine ultimate shear strength of aluminium under single and double shear.
4. Bending Test - To investigate the relationship between load and span on deflection of a simply supported beam subjected to a concentrated load at the centre. Also, evaluate the modulus of elasticity of the given beam from the test data.
5. Impact Test (Charpy and Izod) - To evaluate the energy absorbed during failure of a notched specimen subjected to pendulum impact testing.
6. Brinell hardness Test -To determine the Brinell Hardness Number (BHN) of the given specimens.
7. Vicker's Hardness Test - To determine Vickers Hardness Number for a given specimen.
8. Wear Test - To understand the parameters that affect the wear rate using pin and disc apparatus.
9. Composite preparation- preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process.
10. Demonstration of 3D printing of given polymer/metal/ceramic specimens.

TEXT BOOKS:

1. William D. Callister, Jr.(2020) “Materials Science and Engineering anIntroduction”, 2nd Edition, John Wiley & Sons, Inc.
- V. Raghavan (2019), “Materials Science and Engineering”, Prentice – Hall of IndiaPvt. Ltd.
2. V. Raghavan (2019), “Materials Science and Engineering”, Prentice – Hall of IndiaPvt. Ltd.

REFERENCES:

1. J.M. Shackelford (2014), Introduction to Materials Science for Engineers, 5thEdition, Prentice Hall, Inc.
2. Suryanarayana, A. V. K. (2020), Testing of Metallic Materials, Prentice Hall India,New Delhi.
3. W. Bolton (2013), Engineering materials technology, 3 rd Edition, Butterworth &Heinemann.

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2303					
TITLE OF THE COURSE	ENGINEERING MECHANICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

The objectives of the Course are to

- Explain different types of forces and couples, resolution of forces and couples, equilibrium conditions and related theorems
- Explain concepts of friction and their relevance in Engineering problems
- Describe centroid, center of gravity and differences between them, area moment of inertia, examples of planar objects and computations for them
- Describe Trusses and its classification, assumptions in analysis of trusses, forces in members in a truss
- Calculate various dynamic quantities of translational motion and projectile motion
- Explain principles of dynamics in plane motion analysis

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyze structure using free body diagrams and principle of statics	L3
CO2	Analyze structures using concept of equilibrium conditions considering effect of frictional forces	L3
CO3	Calculate the centroid and moment of inertia of composite geometrical sections	L3
CO4	Compute axial forces in members of determinate truss	L3
CO5	Analyze plane kinematics and kinetics of particles/rigid bodies	L3

COURSE CONTENT:

MODULE 1	8Hrs
Introduction to Engineering Mechanics: Force Systems Basic concepts, Particle Equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Resultant- Moment of Forces and its Application; Couples and	

Resultant of force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium.	
MODULE 2	8Hrs
Friction: Introduction, Types of friction, Limiting friction, Cone of Friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, Ladder friction, related problems.	
MODULE 3	10Hrs
Centroid, Centre of Gravity and Moment of Inertia: Introduction, Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone.	
MODULE 4	8Hrs
Analysis of Truss: Introduction, Classification of trusses, Equilibrium in two and three dimension; Method of Sections; Method of Joints; To determine if a member is in tension or compression; Simple Trusses; Zero force members.	
MODULE 5	8Hrs
Dynamics: Introduction, Rectilinear motion; Plane curvilinear motion (rectangular path, and polar coordinates); Projectile motion, Relative and constrained motion; Basic terms, general principles in dynamics; Types of motion, Instantaneous Centre of rotation in plane motion and simple problems; D'Alembert's principle and its applications in plane motion and connected bodies.	

TEXT BOOKS:

1. A. Nelson (2009), Engineering Mechanics: Statics and dynamics, Tata McGraw Hill publications.
2. Irving H. Shames (2006), Engineering Mechanics, 4th Edition, Prentice Hall publications.

REFERENCES:

1. R.C. Hibbler (2006), Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
2. Bansal R.K (2010), A Text Book of Engineering Mechanics, Laxmi Publications.
3. H.J. Sawant, S.P Nitsure (2018), Elements of Civil Engineering and Engineering Mechanics, Technical Publications.
4. www.dsu.edu.in

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2304					
TITLE OF THE COURSE	THERMODYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- Introduce basic concepts related to thermodynamic system
- Understand Zeroth law of thermodynamics as basis for temperature measurement.
- Define first law of thermodynamics as applied to closed and open systems.
- Explain working of heat engine and refrigeration cycles and to define second law of thermodynamics: Kelvin Planck and Clausius Statement.
- Understand the property entropy through Clausius inequality.
- Understand behavior of ideal and real gases through equation of state and compressibility factor.
- Define pure substance and explain salient points involved in phase change, Plot state diagrams for pure substance.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic concepts of thermodynamics	L2
C02	Apply laws of thermodynamics in temperature measurement, work, heat and other energy interactions of different systems	L3
C03	Analyze system performance based on second law implications	L4
C04	Calculate work, heat, change of energy, change of entropy for closed and open systems executing various thermodynamic processes with and without phase change	L3
C05	Differentiate between ideal and real gas behavior and explain the compressibility factor	L2
C0 6	Calculate thermodynamic properties of a pure substance in a given state	L3

COURSE CONTENT:

MODULE 1	10Hrs

Basic Concepts of Thermodynamics: Introduction- Basic Concepts, Thermodynamic Equilibrium, Thermodynamic properties, Thermodynamic state, state point, path and process, quasi-static process, cyclic and non-cyclic processes, Energy and its forms, Work and heat (sign convention), Zeroth Law of Thermodynamics: Zeroth law of thermodynamics statement, Concept of Temperature and its' measurement, Ideal and Real Gases, Gas laws- Boyle's Law, Charles Law, Gay-Lussac Law, Avogadro's law, equation of state - Vander Waals, Redlich-Kwong, Peng- Robinson etc. compressibility factor.	
MODULE 2	8Hrs
First law of thermodynamics: application to closed and open system, Joules experiments, equivalence of heat and work, Internal energy and enthalpy, energy as a property, specific heat at constant pressure and volume, PMM1, steady state, steady flow energy equation (SFEE), extension of first law to control volume, Limitations of first law of thermodynamics, Extension of SFEE to Various devices like-nozzle, turbine, pump/compressor, heat exchanger	
MODULE 3	8Hrs
Second Law Of Thermodynamics: Thermal reservoirs, , devices converting work to heat in a thermodynamic cycle, heat engine, Efficiency reversed heat engine, heat pump, Refrigerator, Coefficient of Performance, Kelvin- Planck and Clausius statement of second law of thermodynamics, Equivalence of the two statements, reversible and irreversible processes, factors that make a process irreversible, Carnot cycle and Carnot engine, Carnot theorem and its corollaries.	
MODULE 4	8Hrs
Entropy : Clausius Inequality:- Statement, proof, application to a reversible cycle, Entropy: Definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility, Tds equation, calculation of entropy using Tds relations, entropy as a coordinate, Exergy(Available) and unavailable energy, Second law efficiency.	
MODULE 5	8Hrs
Pure substance: Phase change process in a pure substance, Definition of triple, ice, steam and critical points, Property diagrams of pure substance, p-v, p-T, p-h, T-v, T-s diagrams, dryness fraction, use of steam tables.	

TEXT BOOKS:

1. P.Nag (2017), Basic & Applied Thermodynamics, 2nd Edition, Mc Graw Hill Education.
2. Van Wylen, G.J., and Sonntag, R.E., (2002), Fundamentals of Classical Thermodynamics for Engineers, 6th Edition, Wiley.

REFERENCES:

1. Yunus A Cengel and Michael A Boles (2017), Thermodynamics: An Engineering Approach, McGraw Hill Education.
2. Michael J. Moran, Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd, Chichester.

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2305					
TITLE OF THE COURSE	COMPUTER AIDED MACHINE DRAWING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	-	4	-	84	4

Perquisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are to

- Provide overview of various CAD software
- Learn basics of sketching features
- Create 3D models using extrude, revolve, draft & other advanced options
- Introduce assembly concepts
- Create simple & complex mechanical assemblies
- Create industrial standard drawings with appropriate views including sectional views

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Discuss different types of CAD tools	L2
CO2	Create 2D geometric sketches by Autodesk FUSION360.	L3
CO3	Develop 3D models of components using basic and advanced features	L4
CO4	Create different types of assemblies using appropriate constraints	L3
CO5	Produce BOM and manufacturing drawings using appropriate views, symbols & tolerances	L2
CO 6	Discuss applications of CAD data exchange formats	L2

COURSE CONTENT:

MODULE 1		10Hrs
CAD Overview: Preferences-Settings, User Interface- Familiarize the User Interface by creating a simple design, Use of toolbar, marking menu, browser and time line controls, change of workspace, Navigations and data panel interface, Design Units and Origin, Quick Shape Creation.		
MODULE 2		10Hrs
Sketching Workspace: Creating a sketching geometries - Introduction to the Sketching Workflow, Sketch Entities, Dimensioning, Sketch Constraints. Additional Sketching		

Tools- Additional Entity Types, Editing Tools, Additional Dimension Tools, Moving and Copying, Rectangular and circular Patterns. Sketched Secondary Features using existing geometry. Pick and Place Features- Fillets, Chamfers, Holes, Editing Pick and Place Features. Construction of planes, axis and points, creating a sketch using Equation and Parameters.	
MODULE 3	12Hrs
Introduction-Solid Modeling techniques: Constructive Solid Geometry using primitives, Boundary representation & Hybrid methods. Basic Part modelling features- Extrude and revolve. Additional Features and Operations- Draft, Shell, Rib, Split Face, Scale, Thread, Press Pull. Design and Display Manipulation- Reordering, inserting, suppressing Features, Measure and Section Analysis, Direct Modeling Development of multi section solids and sweep. Feature Duplication – mirroring and patterning. Develop the part models and prepare the drafting. List out the operations involved to prepare the components.	
MODULE 4	12Hrs
Distributed Design- Assembly Design Methods, Joint Origins and Assigning Joints. Component Design Tools- Rigid Groups, Interference Detection. Multi-Body Design- Multi- Body Design Tools, Components, As-Built Joints. Drawing Basics-Creating a New Drawing, Additional Drawing Views, Exploded Views, Manipulating Drawings. Detailing Drawings- Dimensions, Parts List and Balloons, Annotation and Dimension Settings, Drawing Output. Data exchange standards – IGES, STP, STL, STEP etc. Develop the assembly drawing from the given detailed drawing(Machine components upto five major parts). Indicate the empirical relations along with actual dimensions and bill of materials. Layout the drawings in A3 sheet.	
MODULE 5	40Hrs
Assembly of Machine Parts: Develop the assembly drawing from the given detailed drawing showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly 1. Swivel bearing 2. Petrol engine connecting rod 3. Cylinder relief valve 4. Machine vice 5. Tailstock 6. Piston of a petrol engine 7. Air valve 8. Fuel Injector 9. Speed reducer 10. Drill jig Layout the drawings in A1 sheet.	

TEXT BOOKS:

1. K. R. Gopalakrishna (2017) "Machine Drawing in First angle projection", Subhaspublication, Bangalore.
2. N.D.Bhat & V.M.Panchal (2016), "Machine Drawing", Charotar Publishing House.

REFERENCES:

1. Basant Agrawal & C M Agrawal (2017) "Engineering Drawing, 2nd Edition ",Mc.Grawhill.

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2306					
TITLE OF THE COURSE	MECHANICAL MEASUREMENTS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

COURSE OBJECTIVES:

The objectives of the Course are to

- Introduce the measurement quantities and measurement standards
- To Study the limits, fits, tolerances and gauges
- Learn the concept of slip gauges and wringing phenomenon
- Study the different types of mechanical and electrical comparators
- Illustrate the linear and angular measurements
- Determine the primary detector-transducers, intermediate signal processing system and terminal systems
- Provide the necessary skills for calibration and testing of different gauges and instruments.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain measurement standards and system	L2
C02	Calculate the uncertainty in measurements	L3
C03	Explain tolerance, limits of size, fits, gauges and the various advancement in laser Interferometers, CMM, Machine Vision Systems	L2
C04	Describe generalized measurement system highlighting various types of sensors, Identify transducers, signal conditioning components, and different types of presentation devices. measurement of temperature, pressure	L2
C05	Calibrate various measuring devices and errors and correction factors of various measuring devices	L2
C0 6	Compute the linear and angular measurements and demonstrate the necessary skills to collect data, perform analysis and interpret results to draw valid conclusions through standard test procedures.	L2

COURSE CONTENT:

MODULE 1	9Hrs
Standards of Measurements in Meteorology: Definition, objectives and concept of metrology, role of standards, standards of length Principles, light wave length	

standards, subdivision of standards, calibration of standards, numerical problems, slip gauges, set of gauges, wringing phenomena, manufacture of slip gauges. Numerical problems on building of slip gauges, Comparators - mechanical, electrical, pneumatic and optical comparators.	
MODULE 2	9Hrs
System of Limits, Fits, Tolerance and Gauging: Indian standards, concept of limits of size and tolerances, interchange ability, selective assembly definition of fits, hole basis system, shaft basis system, types of fits and their designation, geometric tolerance. Classification of gauges, brief concept of design of gauges (Taylor's principles), Numerical problems Advances in Metrology Basic concept of lasers Advantages of lasers, laser Interferometers. Basic concept of CMM, Types of CMM.	
MODULE 3	8Hrs
Measurement systems and its basic concepts: Definition, significance of measurement, fundamental method of measurements, generalized measurement system, definitions and basic concepts, Linear Measurement and angular measurements. Errors in measuring instruments, classification of errors, sources of errors and uncertainty.	
MODULE 4	8Hrs
Introduction to transducers and intermediate modifying devices: Introduction to Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers, Intermediate modifying devices: Mechanical systems, inherent problems, electrical intermediate modifying devices, input circuitry, ballast circuit, electronic amplifiers. Terminating devices, Cathode ray oscilloscope	
MODULE 5	8Hrs
Temperature and Strain Measurements: Temperature Measurement: Resistance thermometers, thermocouples, laws of thermocouple, materials used for construction, pyrometer, optical pyrometer, Strain Measurement: Theory of strain gauges, types, preparation and mounting of strain gauges, gauge factor, Temperature Compensation, Wheatstone bridge circuit.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs
1. Calibration of Micrometer - To calibrate the given micrometer using slip gauge, draw the calibration curve and to evaluate the errors occurred.
2. Calibration of Vernier caliper and measurement of the given component - To calibrate and measure the given component by using Vernier caliper.
3. Calibration of Thermocouple - To calibrate the given T-Type Thermocouple at different temperatures.
4. Calibration of Linear Variable Differential Transformer (LVDT) - To calibrate the given LVDT (for the performance using Vernier height gauge).
5. Calibration of Load Cell - To calibrate the given Cantilever Beam type load cell.
6. Measurements using Optical Profile Projector - To measure the screw thread parameters of a given specimen using Optical Profile projector.
7. Measurements using Toolmaker's Microscope - To measure the screw thread parameters of a given specimen using Tool Maker's Microscope.

8. Measurements of angle using Sine bar - To determine the unknown angle of the given specimen using sine bar with the help of slip gauge.
9. Measurements of angle using universal bevel protractor - To determine the unknown angle of the given specimen using universal bevel protractor.
10. Measurements of Screw thread parameters using two wire or three-wire methods - To find the effective diameter of a given screw thread by two or three wire method.
11. Measurements of gear tooth profile using gear tooth Vernier caliper - To Measure the tooth thickness of the given gear using Gear Tooth Vernier Caliper.
12. Measurements of Vibrations - To study the vibrations measurement, frequency, displacement, velocity & acceleration.
13. Machine tool alignment test on a) Lathe. b) Drilling machine. c) Milling machine. d) CNC milling.

TEXT BOOKS:

1. Beckwith Marangoni and Lienhard (2006), Mechanical Measurements, Pearson Education, 6th Edition.
2. R.K. Jain (2009), Engineering Metrology, Khanna Publishers, New Delhi.

REFERENCES:

1. S.P. Venkatesh (2008), Mechanical Measurements, ANE Publications
2. Ernest O. Doebelin (2019), Measurement Systems: Application and Design, SIE Publications.

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2307					
TITLE OF THE COURSE	SPECIAL TOPICS- 1					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	1	-	2	-	42	2

COURSE OBJECTIVES:

- To Student should be aware with current situation and problems of real world.
- Developing critical thinking
- The gap between the current demand and the conventional teaching can be removed.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Improve their understating more towards real problem.	L2
CO2	Solve the subjective problem using latest available technology.	L3
CO3	Understand different perspective of problem solving using software tools	L2
CO4	Prepare documentation for the solution.	L2

COURSE CONTENT:

Online Mooc Courses
Matlab On ramp Certification for basic Matlab.
Mini Project under the guidance of faculty member
Hackathon
Seminar on Mooc courses and project undertaken.

IV SEM - MECHANICAL ENGINEERING

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2401					
TITLE OF THE COURSE	APPLIED THERMODYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

COURSE OBJECTIVES :

The objectives of the Course are to

- Understand Gas power cycles like Otto, Diesel, Dual and Brayton cycles and calculation of heat, work interactions and thermal efficiency
- Understand Vapour power cycles and calculation of heat, work interactions and thermal efficiency
- Understand the effect of inlet pressure and temperature on the performance of vapour power cycles
- Understand the operation of combined cycle with topping gas turbine and bottoming steam cycle
- Explain the working of a single stage and multistage compressor and to calculate work done, volumetric-isothermal-polytropic efficiencies
- Understand refrigeration cycle and calculation of COP and to study different types of refrigerants and to appreciate the use of eco-friendly refrigerants
- Study combustion thermodynamics of fuels
- Carry out tests to investigate the performance of internal combustion engines

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Calculate work obtained, mean effective pressure and thermal efficiency for Otto, Diesel, Dual and Bryton cycles, Thermal efficiency of Basic, modified, reheat and regenerative Rankine cycles	L3
CO2	Calculate the work done and efficiency for single stage and multistage compressor	L3
CO3	Analyze different refrigeration and air-conditioning cycles	L3
CO4	Analyze combustion thermodynamics of fuels	L3
CO5	Estimate the properties of fuels and lubricants like flash and fire point, viscosity and calorific value.	L2
CO6	Predict I C engine performance parameters at different operating conditions and also to carry out heat balance	L3

COURSE CONTENT:	
MODULE 1	8Hrs
Gas Power Cycles Review of thermodynamics laws, Carnot, Otto, Diesel and Dual Cycles; simple Gas turbine cycle (Brayton cycle) and Modifications; Multistage compression with intercooling, Regeneration, reheat cycles practical gas turbine, cycles; Jet Propulsion cycles	
MODULE 2	10Hrs
Vapour Power Cycles and Combined cycle power plants Components of steam power plant, Carnot vapour power cycles, limitation of Carnot cycle, Simple Rankine cycle; Effect of pressure and Temperature on performance of Rankine Cycle, Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, feed water heaters. Reheat Rankine cycle, Supercritical Rankine cycle, combined gas and vapour cycle power plants. Numerical	
MODULE 3	8Hrs
Reciprocating Compressors Classification; work done in a single stage compressor; efficiency; p-v diagram for an actual compressor and diagram factor; multistage compressor; Multistage compressor with intercooler, Performance parameters for reciprocating compressors	
MODULE 4	8Hrs
Refrigeration and Air conditioning Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Vapour absorption refrigeration system. Psychrometric: Nomenclature, Definition, use of Psychrometric chart, Introduction to air conditioning, different types of air-conditioning systems	
MODULE 5	8Hrs
Combustion Thermodynamics Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions.	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs
Determination of Flash point and Fire point of lubricating oil using Abel, Pensky and Marten's (closed) / Cleavland's (Open Cup) Apparatus.
Determination of Calorific value of solid, liquid and gaseous fuels.
Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
Valve Timing/port opening diagram of an I.C. engine (4 stroke/2 stroke).

Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal Efficiencies, Volumetric efficiency, Mechanical efficiency, SFC, FP, A-F Ratio, heatbalance sheet.

TEXT BOOKS:

1. Kadambi, T. R Seetaraman and K. B Subramanya Kumar (2019), Applications of Thermodynamics, Wiley India Private Ltd, New Delhi.
2. Nag P.K (2017), Basics and applied thermodynamics, Second edition, Tata McGrawHill, New Delhi.

REFERENCES:

1. Yunus A Cengel and Michael A Boles (2017), Thermodynamics: An Engineering Approach, McGraw Hill Education.
2. Michael J. Moran and Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd.

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2402					
TITLE OF THE COURSE	MECHANICS OF MATERIALS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1		-	42	3

COURSE OBJECTIVES :

The objectives of the Course are to

- Explain mechanical properties of materials, Stress, Strain and Hooke's law
- Explain principal stresses, maximum shear stress, principal planes and Mohr's circle for plane stress conditions
- Draw shear force and bending moment diagrams in beams to estimate maximum shear forces and bending moment
- Explain torsional moment of resistance, power transmission of straight and stepped shafts, twist in shaft sections
- Explain strain energy due to axial, shear, bending, torsion and impact load
- Explain theories of failure as applied to materials
- Explain mechanical properties of materials, Stress, Strain and Hooke's law
- Explain principal stresses, maximum shear stress, principal planes and Mohr's circle for plane stress conditions

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Calculate stress and strain for different geometries under different loading conditions	L3
C02	Illustrate principal stresses, maximum shearing stress acting on a structural member using analytical and Mohr's circle method	L2
C03	Calculate the stresses and strains associated with thin and thick cylindrical pressure vessels under axial and circumferential loads	L3
C04	Construct shear force and bending moment diagrams for statically determinate beams	L3
C05	Calculate the shear stress for bodies subjected to torsion and bending stresses for columns	L3
C06	Discuss theories of failure as applied to materials	L2

COURSE CONTENT:	
MODULE 1	8Hrs

Stress and Strain Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them. Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change.	
MODULE 2	10Hrs
Analysis of Stress and Strain Compound Stresses: Principal stresses and maximum shear stress, Planes of Principal stress and Maximum Shear stress, Normal stress on the planes of maximum shear stress, Mohr's circle for plane stress conditions. Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, thin spherical Shell, thin cylinder with spherical ends. Thick cylinders: Lamé's theory.	
MODULE 3	8Hrs
Shear Forces and Bending Moments Shear Forces and Bending Moments: Type of beams, Loads and reactions, Relationship between loads, Shear force and bending moments of cantilever, simply supported and overhanging beams subjected to concentrated loads and uniformly distributed constant / varying loads. Stress in Beams: Bending Theory, Bending and shear stress distribution in rectangular, I and T section beams.	
MODULE 4	8Hrs
Torsion Torsion: Circular shafts, Power Transmission, Torsion of tapered shaft, Shafts in series and Parallel, Thin Tubular and Thin-walled sections. Columns: Euler's theory, Equivalent Length, Limitations of Euler's Formula, Rankine's Formula	
MODULE 5	8Hrs
Strain Energy Strain Energy: Strain energy due to axial, shear, bending, torsion and impact load, Castigliano's theorem and their applications. Theories of Failure: Introduction, maximum principal stress theory (Rankine's theory), Maximum shearing stress theory (Guest's and Tresca's theory), maximum principal strain theory (St. Venant's theory), Maximum Strain energy theory (Haigh's Theory) and Maximum Shear Strain Energy Theory (Mises' and Henkeys's Theory)	

TEXT BOOKS:

1. Stephen Timoshenko (2002), Strength of Materials, 3rd Edition, CBS Publisher.
2. S. S. Bhavikatti (2017), Mechanics of Solids, New Age International Publications.

REFERENCES:

1. F. P. Beer and E. R. Johnston (2020), Mechanics of Materials, 8th Edition, McGraw Hill publications.
2. R. K. Bansal (2010), A Textbook of Strength of Materials, 4th Edition, Laxmi Publications.

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2403					
TITLE OF THE COURSE	FLUID MECHANICS AND MACHINES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

COURSE OBJECTIVES:

The objectives of the Course are to

- Define basic properties of fluids and understand the continuum approximation.
- Define kinematics of Fluid Flow
- Describe Lagrangian and Eulerian Approach for fluid flow
- Buckingham's Pi theorem
- Apply dimensional analysis to design new pumps or turbines that are geometrically similar to existing pumps or turbines
- To study the performance parameters of Reciprocating, Centrifugal and Gear pumps
- To study the performance parameters of Impulse and Reaction turbines like Pelton wheel turbine, Francis turbine and Kaplan turbine
- Define basic properties of fluids and understand the continuum approximation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Define fluid, fluid properties and express fluid properties in terms of various measurable parameters	L1
C02	Explain fluid dynamics and develop relevant fluid dynamic relations considering continuity, momentum and energy equations, apply the relations for analysis of dynamic forces and flow through various geometries	L2
C03	Apply concepts of dimensional analysis to develop mathematical relations for various fluid flow situations	L3
C04	Explain working principles of hydraulic turbomachinery and calculate the power and efficiencies involved in operations of machines and learn concepts of compressible flow	L2
C05	Calculate flow rates of fluids using Orifice meter, Venturimeter, Notches, Rotameter, losses in pipe	L3
C06	Study the performance parameters of Reciprocating, Centrifugal and Gear pumps, Impulse and Reaction turbines like Pelton wheel turbine, Francis turbine	L1

COURSE CONTENT:	
MODULE 1	
8Hrs	
Fluid Properties and Fluid Statics	
Introduction, properties of fluids, viscosity, thermodynamics properties, surface tension and capillarity, vapour pressure. Types of fluid flows Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmospheric and vacuum pressures, Fluid Statics: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid.	
MODULE 2	
10Hrs	
Fluid Kinematics and Dynamics	
Fluid Kinematics- Introduction, Lagrangian and Eulerian Approach for fluid flow, Continuity equation Velocity and acceleration in a flow field, Potential and stream function, Fluid Dynamics	
Introduction, Equation of motion, Euler's equation of motion, and Bernoulli's equation derived from fundamental & Euler's equation, Bernoulli's equation for real fluids. Fluid Flow measurements-Venturimeter, orifice meter and Pitot tube. Flow through Pipes-Major & Minor losses in pipe flow. Numerical exercise.	
MODULE 3	
8Hrs	
Dimensional Analysis and Boundary Layers	
Introduction, Dimensional homogeneity –Buckingham theorem – Non-dimensional numbers – Model laws; Unit Quantities and Specific quantities, introduction to boundary layer theory –Laminar flow and Turbulent flow – Boundary layer thickness.	
MODULE 4	
8Hrs	
Hydraulic Turbines	
Euler's Turbine equation, Classification of turbines, Impulse and reaction turbines, Pelton wheel, Francis and Kaplan turbine –work done and efficiencies. Draft tube theory, Performance of hydraulic machines, unit and specific quantities, turbine governing.	
MODULE 5	
8Hrs	
Pumps	
Classification, working, work done – monometric head- losses and efficiencies- specific speed- pumps in series and parallel-performance characteristic curves, NPSH. Reciprocating pumps: Working, Discharge, slip.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :
28Hrs
1. Rotameter
Calculation of the Rate of Flow Using Rotameter
2. Venturimeter
Determination of the Co- Efficient of Discharge of the Venturimeter

3. Orifice Meter
Determination of the Co-Efficient of Discharge of the Given Orifice Meter
4. Pipe Friction
Determination of frictional loss in a pipe flow
5. Pipe Fittings
Determination of Loss of Head on Pipe Fittings
6. Notch
Determination of Co- efficient of Discharge of the Given Notch
7. Centrifugal Pump
Study of Performance Test On Centrifugal Pump
8. Reciprocating Pump
Study of Performance Test On Reciprocating Pump
9. Gear Pump Test Rig
Study of Performance Test On Gear Pump
10. Pelton Wheel Turbine
Study of Performance Test on Pelton Wheel Turbine
11. Francis Turbine
Study of Performance Characteristics Curves of Francis Turbine

TEXT BOOKS:

1. Bruce R. Munson, Donald F. Young, Theodore H. Okiishi, Wade W. Huebsch (2009)
2. Fundamentals of Fluid Mechanics, John Wiley & Sons Publications. Frank M White (2011),
3. Fluid Mechanics, McGraw-Hill Publication, Seventh Edition

REFERENCES:

1. Jagdish Lal (2016) , Hydraulic Machines, Metropolitan Company book company Limited
2. Yunus A. Cengel, John M. Cimbala (2006), Fluid Mechanics– Fundamental and Applications, Tata McGraw-Hill Publishing Co. Ltd.

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2404					
TITLE OF THE COURSE	MANUFACTURING PROCESS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

COURSE OBJECTIVES:

Theory component:

- To emphasize the importance of manufacturing sciences in the day-to-day life, and to study the basic manufacturing processes.
- To have a broad knowledge on casting process for a given product.
- To understand the importance of metal forming process.
- To understand basic manufacturing processes like casting and welding process.
- To introduce the concepts of powder metallurgy in manufacturing process.
- To identify, discuss, and analyse the manufacturing processes for processing of plastics.
- To impart knowledge and skills to use tools, machines, equipment, and measuring instruments
- To provide knowledge of various casting process in manufacturing.
- To impart knowledge of joining process used in manufacturing.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain significance and engineering applications of various casting processes	L1
C02	Interpret foundry practices like pattern, mold and core making required for Casting process	L2
C03	Differentiate various metal forming processes such as Hot and Cold Working, Rolling, Forging, Extrusion and Drawing Processes	L2
C04	Choose appropriate joining processes for a given application	L3
C05	Construct different types components using casting, welding and smithy shop	L3
C06	Explain working principle and engineering applications of various manufacturing processes.	L1

COURSE CONTENT:

MODULE 1	08Hrs
CASTING PROCESS	

05 hrs

Casting- Introduction, Advantages and applications; Principle of casting processes – Sand casting, Centrifugal casting, pressure die casting, Investment casting, stir casting, solidification of casting, Gating-Principles, requirements and types, Riser – Function, types, design, Defects in castings. Patterns – Types, making, materials and allowances.

MODULE 2

08Hrs

METAL FORMING

Hot working & cold working, plastic deformation, yield criteria, strain hardening, recovery, recrystallization and grain growth. Rolling types & process, drawing types, sheet forming types & process, Extrusion process types, Forging Processes- classification & types- Power forging, Impression die forging, press forging, upset forging, defects in forging.

MODULE 3

10Hrs

WELDING PROCESS

Welding process: Classification, morphology of fusion weld, working principle, Fusion welding: Arc welding- Gas Metal Arc Welding (MIG), Gas Tungsten Arc Welding (TIG), Shielded Metal Arc Welding (SMAW), plasma arc welding, oxyfuel gas welding, Resistance welding- spot, seam, projection, Solid state welding: Friction, friction stir welding, ultrasonic welding, forge welding, electromagnetic pulse welding, hot isostatic pressure welding, Laser welding, Electron beam welding, thermit welding.

MODULE 4

08Hrs

POWDER METALLURGY

Introduction & applications, basic steps, methods of manufacturing powders- Physical, Chemical, Mechanical & Nano powder production methods, mixing of powders, compaction- Pressure less and pressure compaction, explosive compaction, sintering methods, post sintering process, Defects in Powder metallurgy, Characteristics and testing of Metal Powders.

MODULE 5

08Hrs

PROCESSING OF PLASTICS

Classification of Polymers, Forms of raw plastic material, Types and characteristics of plastics, methods of processing plastics, moulding of thermoplastics – working principles and applications, compression moulding, Transfer Moulding, blow moulding, rotational moulding, Film blowing, Thermoforming.

**List of Laboratory/Practical Experiments activities to be conducted (if any) :
28Hrs**

1. **Foundry shop:** Testing of Moulding sand and Core sand - Tensile Strength Test for Core Sand, Compression Test of Molding Sand, Shear Test of Moulding Sand, Permeability Test, Grain Fineness Test, Clay Content Test, Moisture Content Test, Mould Hardness Test, Foundry Model- Preparation of green sand moulds using two

molding boxes kept ready for pouring- Using patterns (Single piece pattern and Split pattern) & without patterns =
2. Forging Operations: Involving upsetting, drawing and bending operations, Simple exercises involving the fabrication of square & hexagonal bolts.
3. Welding shop: Gas welding & Arc Welding
4. Powder Metallurgy: To perform powder compaction of different metal powder by hydraulic press & study the mechanism of sintering (Demo)
5. Industrial Visit- Report making

TEXT BOOKS:

1. P.N. Rao. Manufacturing Technology: Foundry, Forming and Welding, McGrawHill Publication, 5th Edition. (2018)
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 7th Edition, John Wiley & Sons, Inc, New Jersey. (2019)

REFERENCES:

1. Amitabha Ghosh and Asok Kumar Malik (2010), Manufacturing Science, Affiliated East-West Press Ltd.
2. J. T. Black and Ronald A. Kohser (2019) De Garmos Materials and Processes in Manufacturing, John Wiley & Sons, Inc, New York.

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ENC001					
TITLE OF THE COURSE	ECONOMICS FOR ENGINEERS					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	02			-	28	2

COURSE OBJECTIVES:

The objectives of the Course are to

- Understand the importance of economics in engineering decisions as well as day-to-day life and identify various factors of production
- Calculate compound interest, effective interest, nominal interest and the inflation value
- Draw the cash-flow diagram of a firm, calculate their present worth and equivalent annual worth
- Discuss capital budgeting, payback period method, account rate of return method, benefit/cost analysis
- Discuss net present value method, internal rate of return and return on investment
- Explain replacement criteria such as deterioration, obsolescence, inadequacy and cyclic replacements

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the relevance of economics in engineering manufacturing environment.	L1
CO2	Determine the time value of money	L2
CO3	Determine the present worth and equivalent annual worth of the firm's assets and investments.	L2
CO4	Assess the available economic alternatives using traditional and discounted cash flow methods	L3
CO5	Calculate the depreciation value of equipment using different methods	L3
CO6	Perform break-even analysis for a manufacturing company	L3

COURSE CONTENT:

MODULE 1	04Hrs
Basic Concepts of Engineering Economics	

Introduction to Engineering economics, Engineering decision makers, engineering and economics, problem solving and decision making, strategy and tactics, factors of production, Production possibility schedule and curve, marginal rate of transformation, Concept of economic growth	
MODULE 2	03Hrs
Time Value of Money Time value of money - Simple interest, compound interest – nominal interest rate, effective interest rate, and inflation.	
MODULE 3	07Hrs
Present Worth and Equivalent Annual-Worth Comparisons Present worth calculations, Equivalent Annual worth Comparison methods, Situations for Equivalent Annual worth Comparison, Consideration of asset life, comparison of assets with equal and unequal lives.	
MODULE 4	07Hrs
Economic Evaluations Introduction, capital budgeting, importance of capital budgeting, Traditional and discounted cash flow methods of capital budgeting – payback period method, accounting rate of return method, profitability index, net present value method, internal rate of return, Benefit/Cost Analysis, return on investment. break-even analysis	
MODULE 5	07Hrs
Replacement Analysis and Depreciation Replacement due to deterioration, obsolescence, inadequacy, Economic life for cyclic replacements, Depreciation, Causes of Depreciation, Basic methods of computing depreciation charges, Use of sinking fund method.	

TEXT BOOKS:

1. Riggs, J., Bedworth D., & Randhawa S., (2011), Engineering Economics, 4th Edition, McGraw-Hill Education
2. Pindyck, R. S., & Rubinfeld, D. L. (2015), Microeconomics, 7th edition, Pearson Education India

REFERENCES:

1. Panneerselvam R, (2013), Engineering Economics, 2nd edition, Prentice Hall India Learning Private Limited

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2405					
TITLE OF THE COURSE	SPECIAL TOPICS-II					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	01	-	02	-	42	02

COURSE OBJECTIVES:

Theory component:

- Student should be able to solve real world problem
- Student should be aware with more recent technologies.
- Developing Collaborative Learning, Communication skills.
- Student should be able to solve problems in core and intra/inter/multi-disciplinary areas.
- Developing critical thinking and communication skills.
- The gap between the current demand and the conventional teaching can be removed.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Improve their understating more towards real problem.	L2
CO2	Solve the subjective problem using latest available technology.	L3
CO3	Understand different perspective of problem solving.	L2
CO4	Understand the subjective application in different inter/intra/multidisciplinary areas.	L2

COURSE CONTENT:

Online Mooc Courses	
Matlab On ramp Certification for basic Matlab, Machine learning and Deep Learning.	
Mini Project under the guidance of faculty member	
Hackathon	
Seminar on Mooc courses and project undertaken.	

V SEM - MECHANICAL ENGINEERING

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3501					
TITLE OF THE COURSE	Heat Transfer					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	III	20ME2304	Thermodynamics

COURSE OBJECTIVES:

- To understand the basic phenomenon of heat transfer and its importance in engineering applications.
- To enable the students to understand the different modes of heat transfer like conduction, convection and radiation.
- To understand the mechanism of heat transfer under steady and transient conditions
- To illustrate the applications of convective heat transfer including heat exchangers, boiling & condensation
- To understand the different laws of radiation and applying for solving engineering problems

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Compute temperature distribution and heat flow in steady-state and unsteady-state 1-D heat conduction	L3
C02	Calculate forced and free convective heat transfer coefficient and rate of heat transfer	L3
C03	Analyze performance characteristics of heat exchangers	L4
C04	Calculate radiation heat transfer between objects with simple geometries	L3
C05	Demonstrate conduction, convection, and radiation heat transfer phenomena through experiments	L2

COURSE CONTENT:	
MODULE 1	08 Hrs

Modes of heat transfer: Basic laws governing conduction, Thermal conductivity. Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, discussion on 3-D conduction in cylindrical and spherical coordinate system. One dimensional conduction equations for plane, cylinder and spheres. Overall heat transfer coefficient, Thermal conductive resistance and numerical problems. Derivation for heat flow and temperature distribution in a plane for variable thermal conductivity case, critical thickness of insulation and numerical problems.	
MODULE 2	08 Hrs
Introduction, Heat transfer through rectangular fin, infinitely long fin, short fin with insulated tip and without insulated tips. FIN efficiency and effectiveness. Numerical problems. Transient Conduction: Lumped parameter analysis, use of transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, numerical problems	
MODULE 3	10 Hrs
Natural Convection: Introduction, laminar flow, momentum and energy equations for vertical flat plate, physical significance of Grashoff number, use of correlations for free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, numerical problems. Forced Convection: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems.	
MODULE 4	08 Hrs
Fundamental concepts of radiation, different laws governing radiation heat transfer, Stefan-Boltzman law, Kirchoff's law, Planck's law, Wein's displacement law, Intensity of radiation and Lambert's cosine law, Radiation shape factor, Heat exchange by radiation between two black and diffuse gray surfaces, radiation shields, numerical problems.	
MODULE 5	08 Hrs
Heat exchangers: Classification and applications, overall heat transfer coefficient, heat exchanger analysis-Logarithmic mean temperature difference for parallel and counter flow heat exchanger, effectiveness-number of transfer units, method for parallel and counter flow heat exchanger, introduction to cross flow heat exchanger, Logarithmic mean temperature difference correction factor. Numerical problems. Condensation and Boiling: Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation. (no numerical problems).	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Determination of thermal conductivity of metal rod.
2.	Determination of thermal conductivity of composite wall.
3.	Experiment on transient conduction heat transfer.
4.	Determination of heat transfer coefficient in natural convection.
5.	Determination of heat transfer coefficient in forced convection.

6.	Determination of temperature distribution, fin efficiency in natural / forced Convection.
7.	Determination of emissivity of a test surface.
8.	Determination of the emissive power of black body using Stefan's Boltzmann's constant.
9.	Determination of effectiveness and logarithmic mean temperature difference in parallel flow and counter flow heat exchanger.

TEXT BOOKS:

1. Incropera, F.P. and DeWitt, D.P(2011). "Fundamentals of Heat and Mass transfer , John Wiley

REFERENCES:

1. Ozisik(2002.), Heat Transfer-A Basic Approach, Tata Mc Graw Hill.
2. P K Nag (2011), Heat and Mass Transfer, Tata McGrawHill
3. J P Holaman (2009), Heat Transfer, Tata McGrawHill.
4. C.P. Kothandraman, S. Subramanyan(2014), Heat and Mass Transfer Data Book, New Age International Publishers,

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3502					
TITLE OF THE COURSE	Kinematics and Theory of Machines					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	--	-	56	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To impart knowledge on the kinematics and dynamics of planar mechanisms
- analyze the bodies which is in motion using the basics of kinetics and kinematics
- To determine the balancing of masses of rotating and reciprocating machine elements
- To understand the principles of cams, governors and gyroscope
- To familiarize various mechanism by modeling and simulating the final motion in 3D modeling software
- To be able to make completely balanced systems by identify the angular position and spacing between each masses
- To distinguish the performance of different governors by characterize effort, power and sensitiveness
- To understand the gyroscopic principle and verifying its effect by changing the torque

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Discuss the fundamentals of various mechanisms and its inversion	L2
CO2	Perform velocity and acceleration analysis of a particle in a given system and angular velocity of rigid bodies that are in plane motion.	L3
CO3	Solve the problems related to balancing the parts in rotating and reciprocating systems	L3
CO4	Apply the principles of balancing of masses to various systems and engines	L3
CO5	Construct the cam profile for a desired motion. Recognize the fundamentals of governor and gyroscope	L3

COURSE CONTENT:	
MODULE 1	12Hrs
Definitions Link or element, kinematic pairs, chain, Mechanism and Structure, Degrees of freedom, Grubler's criterion. Inversions of various mechanisms. Quick return motion Mechanisms. Straight line motion mechanisms. Intermittent Motion mechanisms. Toggle mechanism, Pantograph, Steering gears mechanism. Universal Hooke's Joint.	
MODULE 2	12Hrs
Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism. Relative velocity and acceleration of particles in a common link and coincident Particles on separate links- Coriolis component of acceleration. Velocity Analysis by Instantaneous Center Method. Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism.	
MODULE 3	12Hrs
Introduction, Static equilibrium. Equilibrium of two and three force members, members with two forces and torque, free body diagrams. Principle of virtual work, static force analysis of various mechanisms with and without friction. Dynamic Force Analysis: D'Alembert's principle, inertia force and torque. Dynamic force analysis of four-bar and slider crank mechanism.	
MODULE 4	10Hrs
Static and dynamic balancing. Balancing of single and several rotating mass. Balancing of single cylinder engine: multi cylinder-inline engine (primary & secondary forces), V-type engine. Balancing of locomotives	
MODULE 5	10Hrs
Types of cams and followers. Development of cam profile for various types of follower and its different motion. Governors: Types of governors; governor characteristics, force analysis of centrifugal governors. Gyroscope: Vector representation of angular motion. Gyroscopic couple, effect of gyroscopic couple on ship, plane disc, aeroplane,	

TEXT BOOKS:

1. Theory of Machines, Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., New Delhi,

REFERENCES:

1. Theory of Machines & Mechanisms, J.J. Uicker, G.R. Pennock, J.E. Shigley. Oxford University Press, 4th Edition, 2010.
2. Theory of Machines, Thomas Bevan, CBS Publication 3rd Edition, 2005.
3. Theory of Mechanisms and Machines: Amitabha Ghosh and Ashok kumar Mallik, 3rd Edition Affiliated East-West Press.1976.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3503					
TITLE OF THE COURSE	Design of Machine Elements-1					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	III	20ME2302	ENGINEERING MATERIALS

COURSE OBJECTIVES:

- Understand the stresses in machine members due to various types of loads and failure of components according to theories of failures.
- Analyze the components under variable loading for infinite and finite life.
- Design of machine elements under torsion, bending, axial loads and a combination of these.
- Design of permanent and temporary joints and fasteners for a given load to be transmitted.
- Design of various screws, keys, coupling and shafts.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Classify various stresses acting on a machine element	L2
CO2	Compute the dimensions of component based on the concepts of failure theories	L3
CO3	Interpret different kinds of loading in mechanical engineering components	L3
CO4	Quantify factor of safety, failure modes for mechanical components subjected to direct and bending and combined loading	L3
CO5	Choose the appropriate keys, coupling, shafts and joints in the design of machine components	L2

COURSE CONTENT:	
MODULE 1	10Hrs

Normal, shear, biaxial and triaxial stresses, stress tensor, principal stresses. Stress-strain diagrams, stress analysis. Design considerations: Codes and standards, design stress, factor of safety, stress concentration factor in tension, bending and torsion, theories of failures, Static Strength: Static loads, Impact Strength: Introduction, impact stresses due to axial, bending and torsional loads, effect of inertia, Failure of brittle and ductile materials	
MODULE 2	08Hrs
Introduction, S-N Diagram, low cycle fatigue, high cycle fatigue, endurance limit, modifying factors: size effect, surface effect, stress concentration effects, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.	
MODULE 3	08Hrs
Threaded fasteners: Stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints. Riveted and Welded Joints: Types, rivet materials, failures of riveted joints, joint efficiency, boiler joints, riveted brackets. Welded Joints: Types, strength of butt and fillet welds, eccentrically loaded welded joints.	
MODULE 4	08Hrs
Joints: Types of keys, design of socket-spigot cotter joint, design of knuckle joint. Couplings: Types of couplings, design of flange and flexible couplings and muff coupling	
MODULE 5	08Hrs
Shafts: Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under fluctuating loads and combined loads. Curved Beams: Stresses in curved beams of standard cross sections used in crane hook	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs	
1.	Determination of principal stresses and strains in a member subjected to combined loading using strain rosettes and verification using FEA tool.
2.	Determination of critical speed of a rotating shaft and verification using FEA tool.
3.	Determination of stresses in curved beam using strain gauge and verification using FEA tool.
4.	Design of Shafts subjected to direct and combined loading for given loads and conditions and comparing design by using CAD/CAE software.
5.	Determination of Fringe constant of Photo-elastic material using. a) Circular disc subjected to diametric compression. B) Pure bending specimen (four point bending)

TEXT BOOKS:

1. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.
2. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

REFERENCES:

1. Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.
2. M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayram and C. V. Venkatesh, Design of Machine Elements Pearson Education, Eighth edition 2019.
3. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.
4. R S Khurmi and J K Gupta, A Textbook on Machine Design, S Chand Publications, Fourteenth Edition 2005.
5. K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.
6. K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3504					
TITLE OF THE COURSE	Manufacturing Technology					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To understand the basic fundamentals and mechanics of metal cutting, tool geometry and life.
- To know the basic knowledge of various machine tools, classification, specification, operations of each machining process like turning, milling, drilling, shaping and grinding operations.
- To impart knowledge on Non-Traditional & CNC machining operation
- To understand the fundamentals of various additive manufacturing technologies for application to various industrial needs

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Choose appropriate machine tools for various machining operations	L3
C02	Identify traditional machining processes for turning, milling, drilling and grinding operations	L3
C03	Classify non-traditional machining processes for advanced machining applications	L2
C04	Analyse working features of CNC machines and part programming	L3
C05	Describe the methods for manufacture of products using 3D Printing technologies	L2

COURSE CONTENT:	
MODULE 1	08Hrs
Types of cutting tool materials, cutting fluids, Single & Multi point cutting tool nomenclature, orthogonal and oblique cutting, mechanism of chip formation, types of chip, merchant analysis, Ernst-merchant's solution, shear angle relationship, problem of merchant's analysis, tool wear and tool failure effects of cutting parameters, tool life criteria, Taylor's tool life equation, problems.	

MODULE 2	08Hrs
Lathe Machine: Classification, features, driving mechanisms of lathe and operations on lathe. Drilling machine: Classification, features & operations. Milling: Classification, features, operations, up and down milling, Indexing concepts. Grinding: Types of abrasives, bonding process, structure & types of grinding wheels	
MODULE 3	10Hrs
Introduction, Classification, Abrasive jet machining, Ultrasonic machining, Water jet machining, Abrasive Water Jet Machining, Electro chemical machining, Electro Chemical Grinding, Electro-discharge machining, Laser beam machining, Electron Beam Machining, Chemical Milling, Photochemical Milling process characteristics – applications, advantages and disadvantages.	
MODULE 4	08Hrs
Fundamentals of numerical control, advantages & classification of NC systems, Functions of MCU, principles of operation features, functions of CNC, Manual part programming, Codes and concepts, point to point and contour programming examples, 2-D simple problems of Drilling, Turning and Milling.	
MODULE 5	08Hrs
Introduction, Prototyping fundamentals, Classification, applications, 3D modeling, Data Conversion and transmission, Post processing, RP data formats, Introduction on liquid, solid and powder based additive manufacturing systems, Case studies.	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs	
1.	To Study of Mechanism in Lathe and Perform Various Operations on a Lathe Machine.
2.	To study tool wear and tool life measurements for machinability
3.	To Study Construction, Working and Performing Operations on a Drilling & Grinding Machine.
4.	To Study Construction and Working of Milling Machine
5.	To Study Construction, Working and Perform of Shaping Operation on a Shaper Machine.
6.	Introduction of Computer Numerical Control Machines and working of few Models on CNC machine.
7.	Study the mechanism and working of 3D Printing machine.

TEXT BOOKS:

1. Serope Kalpak Jain and Steven R. Schmid, “Manufacturing Engineering and Technology”, 7th Edition, Prentice Hall, 2018.

2. P.N. Rao, "Manufacturing Technology – Metal Cutting and Machine Tools,"Volume-II,4 Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2018.

REFERENCES:

1. M. P. Groover, "Fundamentals of Modern manufacturing" -materials, processes and systems Third Edition, Wiley publications, 7th Edition, 2019.
2. Kaushik Kumar, Chikesh Ranjan and Paulo Davim, CNC Programming for Machining, Springer International Publishing, 2020.
3. Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies- 3D printing, rapid prototyping, direct digital manufacturing", Springer International Publishing, 2019.

SEMESTER	V					
YEAR	III					
COURSE CODE	20EME3505					
TITLE OF THE COURSE	Special Topics - III					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	-	-	-	28	2

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- Student should be able to solve problems in core and intra/inter/multidisciplinary areas
- Student should be aware with current technologies
- Developing critical and creative thinking.
- Work in team environment to develop communication skills

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Define problems in core and interdisciplinary and multidisciplinary areas	L2
C02	Solve the subjective problem using current technologies	L3
C03	Demonstrate the interdisciplinary/multidisciplinary approach.	L4
C04	Prepare documentation for the solution.	L3

COURSE CONTENT:	
MODULE 1	12Hrs
Introduction to Python Programming and solving subjective problems.	
MODULE 2	10Hrs
Project under the guidance of faculty members on current semester subjects.	
MODULE 3	10Hrs
Solving subjective problem using software tools (Ansys, Catia, fusion 360)	
MODULE 4	10Hrs
Seminar on projects undertaken.	

PROFESSIONAL ELECTIVE – I

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3506					
TITLE OF THE COURSE	INTRODUCTION TO ROBOTICS AND AUTOMATION					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To introduce the basic concepts, parts and types of robots.
- To make the student familiar with the various sensors, drive systems in robots and programming.
- To discuss about the various applications, justification and implementation of robot.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic principles of Robotic technology, configurations, control and programming of Robots	L2
C02	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
C03	To choose the appropriate Sensor and Machine vision system for a given application	L3
C04	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
C05	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material	

transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	08Hrs
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	08Hrs
Drive system, control system, robot drive mechanisms, hydraulic - electric - servomotor- stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	08Hrs
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	08Hrs
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS:

1. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES:

1. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004..
2. Richard D. Klafter, Robotic Engineering, Prentice Hall of India Pvt., Ltd., 2001.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3507					
TITLE OF THE COURSE	FUNDAMENTALS TO MACHINE LEARNING & ARTIFICIAL INTELLIGENCE					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	--	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES:

- Define machine learning and understand the basic theory underlying machine learning.
- Differentiate supervised, unsupervised and reinforcement learning.
- To present the fundamental principles and practices of AI and ML to address the real-world mechanical engineering problems.
- The course is designed to develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI
- Design and implement a typical AI problem to be solved Using Machine Learning Techniques

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Hand-on experience on Python Programming	L2
CO2	Demonstrate the representation of knowledge and reasoning	L2
CO3	Comprehend the ideas of AI and problem-solving techniques	L3
CO4	Realize Machine Learning techniques in supervised and unsupervised learning	L3
CO5	Recognize the importance of data science, AI & ML in Mechanical Engineering	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Introduction, Basics: Basic types, variables, Decision making and Loops, Strings, Data Structures: Lists, Tuples, Sets, and Dictionaries Regular Expression Operations, Modules. Object oriented programming in python: Classes, Constructors, and Object Methods.	
MODULE 2	10Hrs
NumPy - Overview, NumPy Array creation and basic operations, NumPy Universal	

functions, Selecting and retrieving Data, Data Slicing. Pandas - Overview, Object Creation: Series Object, Data Frame Object, View Data, selecting data by Label and Position, Data Slicing, Setting Data, applying functions to data, Analysing Data for missing values. Matplotlib - Overview, creating basic chart: Line Chart, Bar Charts and Pie Charts, Plotting from Pandas object, Saving a plot.	
MODULE 3	08Hrs
Neural Network basics: History behind neural networks, Relationship between biological neuron and artificial neuron, Perceptron and working mechanism, Architecture of artificial neural network, Types of activation functions.	
MODULE 4	08Hrs
Introduction to Supervised learning, Linear Regression Logistic Regression, Naive Bayes, Decision Tree, KNN, Random Forest, Support Vector Machine Introduction to Unsupervised learning, PCA, clustering approaches: K-means, Hierarchical clustering Natural Language Processing: Language models, n-grams, Vector space models, Bag of words.	
MODULE 5	08Hrs
Machine learning application using python for mechanical engineering datasets: mechanical vibrations - heat transfer - fluid mechanics – manufacturing process. Smart Manufacturing, Smart Transportation and Autonomous Vehicles. Robotics, Quality control.	

TEXT BOOKS:

1. Nagy Z. Artificial Intelligence and Machine Learning Fundamentals: Develop real-world applications powered by the latest AI advances. Packt Publishing Ltd; 2018.
2. Sebastian Raschka and Vahid Mir Jalili, Python Machine Learning, Second Edition: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow Paperback – September 20, 2017

REFERENCES:

1. David L. Poole, Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
2. Nils J. Nilsson, the Quest for Artificial Intelligence, Cambridge University Press, 2009

SEMESTER	V

YEAR	III					
COURSE CODE	20ME3508					
TITLE OF THE COURSE	ADDITIVE MANUFACTURING					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- Understand the importance of additive manufacturing in advance manufacturing process.
- Explore the potential of additive manufacturing in different industrial sectors
- Acquire knowledge, techniques and skills to select relevant additive manufacturing process.
- Apply 3D printing technology for additive manufacturing
- Exploit the technology used in additive manufacturing

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand the working principles and process parameters of additive manufacturing processes	L2
C02	Explore different additive manufacturing processes and suggest suitable methods for building a particular component	L1
C03	Perform suitable Pre & post processing operation based on product repair requirement	L4
C04	Design and develop a working model using additive manufacturing Processes	L6
C05	Able to identify, analyze and solve problems related to Additive Manufacturing	L3

COURSE CONTENT:

MODULE 1: INTRODUCTION TO ADDITIVE MANUFACTURING

06Hrs

Introduction to AM, AM evolution, Historical development, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM.

MODULE 2: ADDITIVE MANUFACTURING PROCESSES

09Hrs

Types, Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping

(LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).	
MODULE 3: ADDITIVE MANUFACTURING MACHINES AND SYSTEMS	09Hrs
Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors. Introduction to NC/CNC/DNC machine tools, CNC programming and introduction, Hardware Interpolators, Software Interpolators, Recent developments of CNC systems for additive manufacturing.	
MODULE 4: PRE-PROCESSING IN ADDITIVE MANUFACTURING	09Hrs
Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.	
MODULE 5: POST-PROCESSING IN ADDITIVE MANUFACTURING	09Hrs
Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing, Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.	

TEXT BOOKS:

1. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
2. Gibson, I, Rosen, D W., and Stucker, B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010

REFERENCES:

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007
2. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
3. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3509					
TITLE OF THE COURSE	AUTOMATED MANUFACTURING SYSTEMS					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- To provide a comprehensive introduction to industrial automation
- To provide comprehensive introduction of various automation systems and related techniques for programming and system analysis.
- To introduce the modelling methods for the performance analysis and design of automation systems

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Appreciate the relevance of industrial automation.	L2
C02	Analyze the performance of automated production lines and automated assembly systems.	L3
C03	Design and draw the functional and logic circuits for the programming of the control elements for automation.	L3
C04	Understand the role of computer-numerical control and robotics in programmable automation and estimate the effectiveness of programmable automation using cycle time analysis	L4
C05	Become familiar with the tools and techniques for automated inspection.	L2

COURSE CONTENT:

MODULE 1: INTRODUCTION

08Hrs

Automation in production systems. Fixed, flexible and programmable automation.

Principles, reasons and strategies for automation.

Automated systems – elements, functions, levels of automation. Continuous Vs discrete

Control. Product/production relationships, Production concepts and mathematical models, Costs of manufacturing operations.

MODULE 2: AUTOMATED PRODUCTION LINES AND AUTOMATED

08Hrs

ASSEMBLY	
Fundamentals of automated production lines. Applications. Analysis of transfer lines with no internal storage. Analysis of storage lines with storage buffers. Fundamentals of automated assembly systems. Design for automated assembly.	
MODULE 3: CONTROL ELEMENTS FOR AUTOMATION	09Hrs
Sensors, Sensors position and velocity feedback. Actuators. Servo control. ADC, DAC. Control of electro-hydraulic and electro-pneumatic systems – Fluid-power symbols and Fluid-power control circuits. Programmable logic controllers – architecture - Ladder logic diagrams.	
	09Hrs
MODULE 4: PROGRAMMABLE AUTOMATION	
NC and CNC units – Part programming – Direct Numerical control – Adaptive control. Robot anatomy – specifications – ends effectors – applications in manufacturing. Robot cell design and control. Robot cycle-time analysis. Flexible manufacturing systems.	
MODULE 5: AUTOMATED MATERIAL HANDLING AND INSPECTION	08Hrs
Automated guided vehicle systems. Automated storage and retrieval systems, carousel storage, and their analysis. Automated inspection systems: Inspection metrology and conventional methods. Coordinate measuring machine. Surface measurement. Introduction to Machine Vision and other optical methods. Non-contact and non-optical inspection techniques.	

TEXT BOOKS:

1. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th Edition, Pearson, 2016..

REFERENCES:

1. B. Benhabib, Manufacturing: Design, Production, Automation and Integration, New York: Marcel Dekker, 2003.
2. Y. Altintas, Manufacturing Automation, Cambridge University Press, 2nd Edition, 2012.
3. J.A. Rehg, Introduction to Robotics in CIM Systems, 5th edition, Prentice Hall, 2003.

SEMESTER	V
YEAR	III
COURSE CODE	20ME3510

TITLE OF THE COURSE	INTRODUCTION TO HYBRID & ELECTRIC VEHICLES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Project s Hours	Total Hours	Credits
	3		-	-	42	3

COURSE OBJECTIVES :

The objectives of the Course are to

- Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
- Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
- Analyze various electric drives suitable for hybrid electric vehicles. Discuss different energy storage technologies used for hybrid electric vehicles and their control.
- Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.	L3
CO2	Analyze the use of different power electronics devices and electrical machines in hybrid electric vehicles.	L3
CO3	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	L3
CO4	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.	L3
CO5	Design and develop the electric propulsion unit and its control for hybrid electric vehicles.	L3

COURSE CONTENT:

MODULE 1	8Hrs

Introduction: State of the Art of HEVs, Challenges and Key Technology of HEVs. Hybridization of the Automobile: Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs). HEV Fundamentals: Introduction, Vehicle Model, Vehicle performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics.	
MODULE 2	8Hrs
Plug-in Hybrid Electric Vehicles: Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, Component Sizing of EREVs, Component Sizing of Blended PHEVs, Vehicle-to-Grid Technology. Power Electronics in HEVs: Power electronics including switching, AC-DC, DC-AC conversion, electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics.	
MODULE 3	10Hrs
Electric Machines and Drives in HEVs: Introduction, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors.	
MODULE 4	8Hrs
Batteries, Ultracapacitor, Fuel Cells, and Controls: Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.	
MODULE 5	8Hrs
Integration of Subsystems: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems. Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.	

TEXT BOOKS :

- 1 Husain, I. (2010). Electric and hybrid vehicles: design fundamentals. CRC press.
- 2 Eshani, M., Gao, Y., Gay, S. E., & Emadi, A. (2005). Modern electric, hybrid electric and fuel cell vehicles. Fundamentals, Theory, and Design. Boca

Raton, FL: CRC.

REFERENCES :

1. Laraminie, J., & Lowry, J. (2003). Electric vehicle technology explained.
2. Chris, M., Masrur, M. A., & Gao, D. W. (2011). Hybrid electric vehicles: principles and applications with practical perspectives. Masrur, David Wenzhong Gap.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3511					
TITLE OF THE COURSE	AUTOTRONICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	3		-	-	42	3

COURSE OBJECTIVES :

The objectives of the Course are to

- Learn the basics of electrical and Laws.
- Study about the electrical safety and importance of the earthing.
- Study the construction and principle of DC motor and its types.
- Understand about the generator, alternator, regulator and starting motor and mechanism.
- Study about the different ignition system.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Recognize and understand different wiring diagrams used in manufacturer's workshop manuals.	L3
CO2	Identify the various modules and sensors from the wiring diagrams.	L3
CO3	determine the function and operation of various electronic components	L3
CO4	Understand their role in the management of the vehicle control	L3

C05	Understand construction and working of different electric and hybrid vehicles.	L3

COURSE CONTENT:	
MODULE 1	8Hrs
INTRODUCTION : AUTOMOTIVE ELECTRICAL SYSTEMS : Automotive electric power generation, Storage & Distribution systems, Wiring harness, Circuit diagrams and symbols, 12/24/42 volt system, Positive earth and negative earth, Earth return and insulated return systems, Multiplexed wiring systems, Electromagnetic compatibility, Electromagnetic interference, Controlled Area Networks (CAN) Battery: Types, Principle of lead acid battery, Constructional details, Recharging the battery, Battery ratings, Battery Performance, Battery capacities, Battery efficiency, Battery tests, Battery failures, Alkaline battery, Maintenance free batteries, Hybrid batteries	
MODULE 2	8Hrs
CHARGING SYSTEMS & REGULATORS : Generators, A. C. Generators, Magneto Constant current & Voltage systems, Current & Voltage regulator, Semi-conductor type regulator, Regulator for alternators Starting Systems: Requirements of Starting system, Starting system layout, Selection of motor, matching battery, Drive mechanisms, Permanent magnet motors	
MODULE 3	10Hrs
IGNITION SYSTEMS: Introduction, Types, Ignition coil, Distributor, Cam angle & Contact angle gap, Advance mechanisms, Ballast Resistance, Limitations of coil Ignition, Transistorized Ignition systems, Spark plugs, types, Construction. LIGHTING SYSTEMS: Fundamentals, Headlight, Types, Lighting circuits, Interior lighting, Signaling, LED lighting, Gas discharge lighting	
MODULE 4	8Hrs
AUTOMOTIVE EQUIPMENT & ACCESSORIES: Fuel gauge, Oil pressure gauge, Temperature gauges, Speedometer, Warning Lights, Electric Horn, Horn Relay, Wind Shield wipers, Heaters & Defrosters, Electric windows. AUTOMOTIVE SENSORS & ACTUATORS: Actuators, Air-flow rate sensor, Angular position sensor, Throttle angle sensor, Temperature sensor, Knock sensor, Pressure sensor. Feedback for engine control, Solenoid actuators, Motorized actuators.	
MODULE 5	8Hrs

AUTOMOTIVE ELECTRONIC SYSTEMS: Electronic Ignition systems, Electronic injection systems, Antilock brake system circuit, Traction control, Electronic control of automobile transmission, Active suspension, Engine management system.

ELECTRONIC AND HYBRID VEHICLES : Types, Energy sources – batteries, Fuel cells, Solar and Hydrogen, Electric machines and controllers, Design considerations, Challenges and recent developments.

TEXT BOOKS :

- 1 Kohli, P. L. (1983). Automotive electrical equipment. Tata McGraw-Hill Publishing Company.
- 2 Denton, T. (2017). Automobile electrical and electronic systems. Routledge.

REFERENCES :

1. Ribbens (2013.), "Understanding Automotive Electronics", 7th Edition, Elsevier, Indian Reprint,
2. Tom Denton (2000), "Automobile Electrical and Electronics Systems", Edward Arnold Publishers.
3. Barry Hollembeak (2001), "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3512					
TITLE OF THE COURSE	REFRIGERATION AND AIR CONDITIONING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- Study the methods of refrigeration, Carnot cycle, Unit of refrigeration and coefficient of performance
- Discuss classification and properties of refrigerants
- Describe the Vapour compression and Vapour absorption systems
- Understand psychrometric properties and processes

- Study Air conditioning systems and air conditioning loads
- Understand the measuring instruments and sensors used in air conditioning

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain different methods of refrigeration	L2
CO2	Select the suitable refrigerant based on application and environmental consideration	L3
CO3	Analyse Vapour compression and Vapour absorption refrigeration systems	L4
CO4	Apply the knowledge of psychrometric properties and processes for air conditioning	L3
CO5	Compute air conditioning loads and Interpret air conditioning methods	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Methods of refrigeration, ice refrigeration, evaporative refrigeration, air refrigeration, vapour refrigeration, dry ice refrigeration, pulse tube refrigeration, thermo-acoustic refrigeration, reverse Carnot cycle, block diagram of refrigerator & modified reverse Carnot cycle (Bell Coleman cycle). Unit of refrigeration and coefficient of performance.	
MODULE 2	08Hrs
Refrigerants: Classification of refrigerants, desirable properties of refrigerants, environmental issues, Ozone depletion potential and global warming potential & life cycle climate performance. Selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes.	
MODULE 3	10Hrs
Vapour Compression Systems: Vapor compression cycle: p-h and T-s diagrams – deviations from theoretical cycle – sub cooling and super heating-effects of condenser and evaporator pressure on COP- multi pressure system – low temperature refrigeration – cascade systems – problems. Vapour Absorption Systems: Introduction, working of simple vapour absorption system, desirable properties of binary mixture (aqua-ammonia), Lithium-Bromide (Li- Br) absorption system, performance evaluation, applications and comparison between vapour compression system and vapour absorption system.	
MODULE 4	08Hrs

Properties of moist air-Gibbs Dalton law, specific humidity, dew point temperature, degree of saturation, relative humidity, enthalpy, humid specific heat, wet bulb temperature thermodynamic wet bulb temperature, psychrometric chart; psychrometric processes.	
MODULE 5	08Hrs
Air conditioning: Introduction, Classification, ASHRAE Nomenclature, Applications, Different Air-Conditioning Systems: Central, Unitary, Window, Packaged & Transport Air conditioning loads: Outside and inside design conditions; Sources of heat loads and calculations; Air filters; air conditioning systems with controls: temperature, pressure and humidity sensors, actuators & safety controls.	

TEXT BOOKS :

1. Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill, 2008.
2. Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 1983.

REFERENCES :

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000
2. Domkundwar, V.M (2014), Refrigeration and Air-Conditioning Data Book, Dhapapatraihill, 1998.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3513					
TITLE OF THE COURSE	TOOL DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES :

- To understand the various types of tooling materials and their industrial applications.
- To develop capability to design and select single point and multipoint cutting tools for various machining operations.
- Exposure to variety of locating and clamping methods available.
- To enable the students to design jigs and fixtures for simple components
- To expose the students to the design/selection procedure of sheet metal and injection mold

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Select appropriate cutting tools required for producing a component.	L2
CO2	Apply design concepts of single point and multi-point cutting tools	L3
CO3	Demonstrate knowledge of various press tools and sheet tool operations.	L2
CO4	Classify and explain various types of injection moulding dies.	L4
CO5	Analyze and design a jig/fixture for a given simple component	L4

COURSE CONTENT:	
MODULE 1	08Hrs

Different tooling materials: cemented carbides, coated carbides, cermet's, ceramics and polycrystalline tool materials. Selection and properties of tool materials, plastics as tool materials, Tooling materials – properties and applications of ferrous, non-ferrous and non-metallic materials. Case studies.	
MODULE 2	08Hrs
Design of single point cutting tools - various systems of specifications, geometry and their interrelation, theories of formation of chip and their effect. Design of multipoint cutting tools – Design elements, nomenclature and geometry of drill bit, milling cutter, reamer and broaching tool. Cutting parameters and machining time calculation for drilling, milling, reaming and broaching operation. Case studies	
MODULE 3	10Hrs
Working of a power press and classification of presses. Press working terminology, Types of dies-Simple, progressive, compound and combination dies. Components of a simple die, press tool operation, die accessories, press tool operations. Shearing theory, cutting clearance between punch and die, methods of reducing cutting forces, Centre of pressure and problems, scrap strip layout. Design problems on blanking and piercing dies for simple components. Case studies	
MODULE 4	08Hrs
Injection moulding machine and its elements, general configuration of a two plate mould. Introduction to gate, runner, parting surface, ejection system. Core and cooling system. Design problems on injection mold. Case studies	
MODULE 5	08Hrs
Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures. Location: 3-2-1 Principle of location, different types of locating elements. Clamping: Principles of clamping, types of clamping devices. Drill jigs: Different types, Types of fixtures: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centres, and modular fixtures. Case studies.	

TEXT BOOKS :

1. Donaldson. C, Lecain.G.H and Goold.V.C, Tool Design, Tata McGraw Hill publishing company limited, New Delhi, 2002.

REFERENCES :

1. Surendra Kenav and Umesh Chandra, Production Engineering Design (Tool Design), New Delhi, 1994.
2. Mehtha.N.K, Machine Tool Design and Numerical Control, Tata Mc-Graw Hill, Third Edition, 2012.

VI SEM - MECHANICAL ENGINEERING

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3601					
TITLE OF THE COURSE	Design of Machine Elements - II					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV	20ME2402	Mechanics of Materials

COURSE OBJECTIVES :

- To understand use of different types of springs and determine safe design of spring under static and fluctuating loading conditions.
- To understand the standard nomenclature, forces, failures, application, design procedure of Spur and Helical gears (As per AGMA)
- To understand the standard nomenclature, forces, failures, application, design procedure of Bevel and Worm gears (As per AGMA) and to determine standard geometry under given loading condition
- To understand the design procedure, failures and application of Ball Bearings and Sliding contact bearing
- Design clutches and brakes required for power transmission.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Classify different kinds of springs, gears, bearings,clutches and brakes.	L2
CO2	Compute tooth strength for spur, helical, bevel and worm gears	L3
CO3	Interpret the pressure distribution in a journal bearing.	L3
CO4	Analyze the design of hydrodynamic journal bearing.	L4
CO5	Select suitable clutch plate and break shoe for a given applications.	L2

COURSE CONTENT:	
MODULE 1	08Hrs
Springs: Types, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, springs under fluctuating loads. Leaf springs: Stresses in leaf springs. Equalized stresses, energy stored in springs, torsion, Belleville and rubber springs.	
MODULE 2	10Hrs
Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear load. Helical Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads.	
MODULE 3	08Hrs
Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads. Worm Gears: Definitions, design based on strength, dynamic, wear loads and efficiency of worm gear drives.	
MODULE 4	08Hrs
Bearings: Lubricants and their properties, mechanisms of lubrication bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, Heat dissipated, bearing materials, examples of journal bearing and thrust bearing design.	
MODULE 5	08Hrs
Clutches & Brakes: Design of clutches: Single plate, multi plate and cone clutches. Design of Brakes: Block and band brakes: Self-locking of brakes: Heat generation in brakes.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Determination of pressure distribution in journal bearing
2.	Modelling and stress analysis of Spur and Helical Gear tooth by using CAD/CAE software
3.	Modelling and stress analysis of helical and leaf springs using CAD/CAE software
4.	Modelling and stress analysis of brake by using CAD/CAE software
5.	Modelling and stress analysis of single plate and multi-plate clutches by using CAD/CAE software
6.	Open ended project using FEA software

TEXT BOOKS :

1. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.
2. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition, 2007.

REFERENCES :

1. Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.
2. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.

3. K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.
4. K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3602					
TITLE OF THE COURSE	Finite Element Methods					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1.			

COURSE OBJECTIVES :

- To help students to differentiate between finite difference and finite volume methods
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range two-dimensional real world structural and thermal problems
- To help students understand the use of higher order finite elements

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Differentiate between finite difference and finite volume methods and their applications.	L3
CO2	Analyze a wide range two-dimensional field problems using finite element techniques	L2
CO3	Apply FE techniques to situations involving heat transfer by conduction	L3
CO4	Apply FE techniques in structural and solid mechanics	L3
CO5	Appreciate the use of higher order elements in FEM and apply the same	L3

COURSE CONTENT:	
MODULE 1	10Hrs

Introduction to computational methods, Finite difference method, Finite volume methods, Direct stiffness method, Integral formulation for numerical Solution – Variational method, Method of weighted residuals, Potential energy formulations; Principle of virtual work, Division of the region into elements - One dimensional linear element, Linear triangular element, Bilinear rectangular element, Representation for scalar and vector fields, Global, local and natural coordinate systems in one, two and three dimensions.	
MODULE 2	08Hrs
Governing differential equations; Integral equations for the element matrices, Triangular element matrix, Torsion of noncircular sections, General theory – Twisting of a square bar, Shear stress components, Evaluation of the twisting torque, Flow of an Ideal Fluid – Potential Formulation, Groundwater Flow, Flow Around a Cylinder, Other field problems, Derivative boundary conditions – 1D, Derivative boundary conditions – 2D,	
MODULE 3	08Hrs
Heat transfer by conduction, The one dimensional fin – 1, The one dimensional fin – 2, The composite walls, The two-dimensional fin, Boundary conditions, Long two-dimensional bodies – 1, Long two-dimensional bodies – 2, Axi-symmetric field problems, The differential equation – Axi-symmetric elements, Galerkin's method, Element matrices,	
MODULE 4	08Hrs
The axial force member - Element matrices, The truss element – Element matrices, Analysis of a pinned truss – 1, Analysis of a pinned truss – 2, A Beam element, Shape functions, Element matrices, Analysis of a statically indeterminate beam – 1, Analysis of a statically indeterminate beam – 2, A plane frame element – Element matrices, Two dimensional stress analysis - Stress, strain and Hooke's Law, The strain displacement equations, Two dimensional elasticity - Plane stress and plane strain, The displacement equations, The element matrices, Element stresses, Axi-symmetric stress analysis - Element matrices, Surface loads,	
MODULE 5	08Hrs
Iso-parametric elements in one and two dimensions, use of higher order elements, Element matrices, Introduction to Transient domain & Dynamic analysis, Changing the variables of integration- One-dimensional integrals, Two-dimensional integrals, Numerical Integration techniques- one-dimensional integrals, Quadrilateral regions, Triangular regions; Evaluating [B]; Evaluating the surface integrals, Pre and post processing, capability of commercially available FEM packages, Error analysis	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28	
1.	Bars of constant cross section area, tapered cross section area and stepped bar

2.	Trusses (Minimum 2 exercises) Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc; (Minimum 6 exercises)
3.	Dynamic analysis 1) Fixed – fixed beam for natural frequency determination 2) Bar subjected to forcing function 3) Fixed – fixed beam subjected to forcing function
	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises)
4.	Stress analysis of a rectangular plate with a circular hole

TEXT BOOKS :

1. “Applied Finite Element Analysis”, L.J.Segerlind, John Wiley and Sons
2. “Applied Finite Element Analysis”, G.Ramamurthy, I.K.International Publishing House ,2009

REFERENCES :

1. “Concepts and Applications of Finite Element Analysis”, Cook, R. D., Malkus, D. S., Plesha, M. E., and Witt, R. J. Wiley Student Edition, Fourth Edition, First Reprint 2007.
2. “The Finite Element Method in Engineering”, Rao, S. S., Butterworth-Heinemann (An imprint of Elsevier), Published by Elsevier India Pvt. Ltd., 2007.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3603					
TITLE OF THE COURSE	Mechanical Vibrations					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

- To learn analytical, experimental, and numerical analysis of vibrational phenomena.
- To learn the mathematical modelling of mechanical systems
- To understand the application of the law of conservation of energy in solving problems through energy methods.
- To understand the importance of damping in mechanical systems
- To design the vibration absorbers and isolators
- To acquaint with the principles of vibration measuring instruments

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Construct mathematical models to represent dynamic systems	L3
CO2	Analyse vibratory responses of single, two and multi degree of freedom mechanical systems	L4
CO3	Demonstrate the knowledge of vibration measuring instruments	L3
CO4	Apply AI techniques to Vibration Analysis of mechanical systems	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction, classification of vibration systems, harmonic motion, natural frequency & response, effects of vibration, superposition of simple harmonic motions, Single degree freedom system- equation of motion, Free vibration, equivalent systems, torsional vibrations, vibrations of systems with viscous damping, Logarithmic decrement, energy dissipation in viscous damping.	
MODULE 2	08Hrs
Forced vibration, harmonic excitation with viscous damping, steady state vibrations, forced vibrations with rotating and reciprocating unbalance, support excitation, vibration isolation, transmissibility, displacement, velocity and acceleration measuring instruments.	
MODULE 3	08Hrs
Introduction, principal modes, torsional system with damping, coupled system, principle of vibration absorber, undamped dynamic vibration absorbers, torsional vibration absorber, centrifugal pendulum absorbers, vibration isolators and dampers.	
MODULE 4	08Hrs
Numerical Analysis- Influence coefficients, reciprocal theorem, torsional vibration of multi-degree rotor system, Rayleigh's method, Dunkerely's, Holzer's and Stodola methods, Rayleigh-Ritz method, critical speed of shafts, whirling of uniform shaft, shaft with one disc with and without damping, multi-disc shafts, secondary critical speed.	
MODULE 5	08Hrs
Vibration instruments – transducer, vibrometer, accelerometer, seismometer, vibration pickup, proximity probe spectrum analyzer, principle of seismic instruments, frequency measuring instruments, diagnostic tools, Introduction to condition monitoring and fault diagnosis using Artificial Intelligence approach.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Plotting and analysis of various graphs of free and forced vibrations using MATLAB.
2.	Virtual lab exercises provided by MHRD
3.	Free and forced vibration
4.	Whirling of the shaft and finding the critical speed of the shaft.
5.	Students will be trained in MATLAB and ANSYS for solving simple vibration problems and using AI & ML techniques in condition monitoring.

TEXT BOOKS :

1. Rao.S.S, Mechanical Vibrations, 6thEdition, Pearson Education Inc. Delhi 2018.
2. Thomson.W.T, Theory of Vibration and its Applications, 5thEdition, Prentice Hall, New Delhi, 2001.

REFERENCES :

1. Rao.J.S and Gupta.K, Introductory Course on Theory and Practice of Mechanical Vibrations, New Age International, New Delhi, 1999.
2. Ramamurthi.V, Mechanical Vibration Practice with Basic Theory, 1st Edition, Narosa Publishing House, Chennai, 2000.
3. Keith Mobley.R, Vibration Fundamentals, Plant Engineering Maintenance Series, Elsevier, 2007.
4. S.Graham Kelly, Mechanical Vibrations - Schaum's outline series, McGraw Hill, 2007

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ENC002					
TITLE OF THE COURSE	LAW FOR ENGINEERS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	-	-	-	28	2

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	--	--	--

Course Objectives:

The students will be able to

1. Apply the knowledge of the constitutional literacy to become aware of the

- fundamental rights and duties in their role as Engineers
2. Understanding of ethical and legal aspects of advertising, consumer problems and their redressal mechanism related to product and service standards.
 3. Demonstrate an advanced and integrated understanding of the nature and extent of the corporate entity principle and to understand how this principle applies to corporate groups
 4. Critically evaluate the extent and application of the Corporate Law.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand process of ethical and moral analysis in decision making scenarios and inculcate ethical behavior as a trait for professional development.	L1
CO2	Apply the knowledge to solve practical problems with regard to personal issues & business enterprises.	L3
CO3	Identify the conflict management in legal perspective and judicial systems pertaining to professional environment; strengthen the ability to contribute to the resolution of human rights & Ragging issues and problems through investigative and analytical skills.	L2

COURSE CONTENT:

Module I: Introduction		08 Hrs
Introduction to Indian legal system, Review of Constitution of India, Sources of Law and Judicial system. Contracts and its Elements: Employment contracts, Contract Interpretation, service contract , Contract of Indemnity, Law of Agency, Employment Agreement		
Module II : Legal documentation		08 Hrs
Legal documentation: Drafting of legal documents including Non-Disclosure Agreements (NDA) , Request for proposal (RFP), Collaboration Agreement , Joint Venture Agreements, Tendering and sub-contracting		
Module III: Property Rules, Trademarks & Copy Rights		10 Hrs
Intellectual Property Rules (IPR) Overview, Trademarks , Copy Rights , Patents with special emphasis in Biotechnology Inventions, Software Circuits and Design, Protection in Foreign Countries		
Module IV: Introduction to Labour and Environmental Laws		08 Hrs
Labour Laws: Provident Fund, ESIC, Gratuity, Bonus, Perquisites, Contract labour, Health, Safety and welfare of construction workers, Introduction to Environmental Law, Concept of Law & Policy , Environment and Governance ,Sustainable Development and Environment , Understanding Climate Change and its processes – CDP, CDMs and Carbon Off Setting, Overview of International		

Environmental Laws, Introduction to Environment and IPR	
Module V: Cyber Laws & Taxation	
Cyber Laws , E-Commerce and E-Governance, Taxation: Income Tax, Service Tax, VAT, Excise Duty, RTI Act.	
	10 Hrs

Text books:

1. V.S. Datey, Indirect Taxes: Law and Practice, Taxmann Publications (P) Ltd, Latest Edition Publications (P) Ltd, latest Edition.
2. S.C. Srivastava, Industrial Relations and Labour Laws, Vikas Publishing House Pvt.Ltd.
3. Joseph Minatiur, Indian Legal System, Indian Law Institute, New Delhi.

Reference books:

1. Kamith Seth, Computer Internet and New Technology Laws, LexisNexis, First Edition 2013.
2. Prafulla C Pant, The Arbitration and Conciliations Act, 1996, ButterworthsIndia, New Delhi..
3. J. Beatson, Anson's Law of Contract, Oxford University Press.

PROGRAM ELECTIVE – II

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3604					
TITLE OF THE COURSE	DRIVES & CONTROL SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- To help students to differentiate between Servos and controls.
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range servo and control problems.
- To help students understand the use of different drives and power rating.
- To help students to differentiate between Servos and controls.
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range servo and control problems.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.	L2
C02	Discuss the concept of transfer functions for the representation of differential equations	L3
C03	Discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.	L3
C04	Represent servo drive components by their transfer function, to combine the servo drive building blocks into system block diagrams.	L3
C05	Determine the frequency response techniques for proper servo compensation.	L3

COURSE CONTENT:

COURSE CONTENT:	
MODULE 1	8Hrs
ELECTRICAL DRIVES Electrical Drives: Electrical Drives, Advantages of Electrical Drives. Parts of Electrical Drives, Choice of Electrical Drives, Status of dc and ac Drives. Dynamics of Electrical Drives: Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation. Equivalent Values of Drive Parameters, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations, SteadyState Stability, Load Equalization. Control Electrical Drives: Modes of Operation, Speed Control and Drive Classifications, Closed loop Control of Drives.	
MODULE 2	8Hrs
SELECTION OF MOTOR POWER RATINGS Selection of Motor Power Ratings: Thermal Model of Motor for Heating and Cooling, Classes of Motor Duty, Determination of Motor Rating. Direct Current Motor Drives: Controlled Rectifier Fed dc Drives, Single Phase Fully Controlled Rectifier Control of dc Separately Excited Motor, Single Phase Half Controlled Rectifier Control of dc Separately Excited Motor, Three Phase Fully Controlled Rectifier Control of dc Separately Excited Motor, Three Phase Half Controlled Rectifier Control of dc Separately Excited Motor, Multi quadrant Operation of dc Separately Excited Motor Fed Form Fully Controlled Rectifier, Rectifier Control of dc Series Motor, Supply Harmonics, Power Factor and Ripple in Motor Current, Chopper Control of Separately Excited dc Motor, Chopper Control of Series Motor.	

MODULE 3	10Hrs
INDUCTION MOTOR DRIVES Analysis and Performance of Three Phase Induction Motors, Operation with Unbalanced Source Voltage and Single Phasing, Operation with Unbalanced Rotor Impedances, Analysis of Induction Motor Fed From Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources.	
MODULE 4	8Hrs
SYNCHRONOUS MOTOR DRIVES Voltage Source Inverter (VSI) Control, Cyclo-converter Control, Closed Loop Speed Control and Converter Rating for VSI and Cyclo-converter Induction Motor Drives, Variable Frequency Control from a Current Source, Current Source (CSI) Control, current regulated voltage source inverter control, speed control of single phase induction motors.	
MODULE 5	8Hrs
PERFORMANCE CRITERIA Percent Regulation, Servo System Responses. Servo Plant Compensation Techniques: Dead-Zone Nonlinearity, Change-in-Gain Non-linearity, Structural Resonances, Frequency Selective Feedback, Feedforward Control. Machine Considerations: Machine feed drive Considerations, Ball Screw Mechanical Resonances and Reflected Inertias for Machine Drives.	

TEXT BOOKS :

- 1 "Industrial Servo Control Systems Fundamentals and Applications", George W. Yountkin, 1st Edition, 2003.
- 2 Fundamentals of electrical drives by G K DUBEY, Narosa publications, 2005

REFERENCES :

- 1 "Servo Motors and Industrial Control Theory", Riazollah Firoozian, R. Springer, 2nd Edition, 2014.
- 2 "DC SERVOS Application and Design with MATLAB", Stephen M. Tobin, CRC, 1st Edition, 2011.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3605					
TITLE OF THE COURSE	ELECTRICAL MACHINES AND POWER SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	3	-	-	-	48	3

Pre-requisite Courses (if any)			
#	Sem/Yea r	Course Code	Title of the Course

COURSE OBJECTIVES:

The course will enable the students to:

1. To make the students understand the working principle of transducers and sensors.
2. To understand various types of lighting system and charging system..
3. To understand various types of sensors used in engine and application of each sensor.
4. To have a broad knowledge about electrical and electronic components in the vehicle

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	To explain various electronic systems present in the vehicle.	L1
C02	To do demonstrate on quantity of energy conversion through calculations for actual processes	L2
C03	The student will know about the Automatic Transmission and Applications of Automatic Transmission	L1
C04	To explore current trend automotive electronic engine management.	L2
C05	The student will understand the principle and working of the clutch, gearbox	L1

COURSE CONTENT:	
MODULE 1: BATTERIES AND ACCESSORIES	08hrs
Principle and construction of lead acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on batteries, maintenance and charging	
MODULE 2: STARTING SYSTEM	08hrs
Condition at starting, behaviour of starter during starting, series motor and its characteristics, principle and construction of starter motor, working of different starter drive units, care and maintenances of starter motor, starter switches.	
MODULE 3: CHARGING SYSTEM AND LIGHTING	10 hrs
Generation of direct current, shunt generator characteristics, armature reaction, third brush regulation, cut-out. Voltage and current regulators, compensated voltage regulator, alternators principle and constructional aspects and bridge rectifiers, new developments.	
Lighting system: insulated and earth return system, details of head light and side light, LED lighting system, head light dazzling and preventive methods – Horn, and wiper system, advances in lighting system (adaptive front lighting system – AFLS).	
MODULE 4 FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS	08 hrs
Current trends in automotive electronic engine management system, electromagnetic interference suppression, electromagnetic compatibility, electronic dashboard instruments, on board diagnostic system, security and warning system.	
MODULE 5 SENSORS AND ACTUATORS	08 hrs
Types of sensors: sensor for speed, throttle position, exhaust oxygen level, manifold pressure, crankshaft position, coolant temperature, exhaust temperature, air mass flow for engine application. Solenoids, stepper motors, relay. Case study of any one of the automotive sensor-based application.	

TEXTBOOKS:

1. Allan Bonnick, "Automotive Computer Controlled Systems", 2011.
2. Tom Weather Jr and Cland C. Hunter, "Automotive Computers and Control System", Prentice Hall Inc., New Jersey.

REFERENCES:

- 1 Santini Al, "Automotive Electricity and Electronics", Cengage Learning, 2012
- 2 Tom Denton, "Automotive Electrical and Electronic System", SAEInternational, 2004.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3606					
TITLE OF THE COURSE	MATERIALS FOR ADDITIVE MANUFACTURING					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- Understand the importance of materials in additive manufacturing for various advanced process.
- Learn the concepts and the role of materials in material design and quality aspects
- Understand the various types of simulation and mathematical models and their practical use
- Utilize material handling equipment in manufacturing situations
- Have wide knowledge on usage of additive manufacturing in various applications

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Determine the appropriate materials for manufacturing process for the product to be made.	L1
C02	Analyze the suitability of a manufacturing process to convert the raw material to designed specifications.	L4
C03	Developing the material ability and expertise to apply the latest mathematical tools and techniques for computing and engineering practice.	L5
C04	Perform cost analysis for various manufacturing process to minimize the cost of processing the material.	L2
C05	Application of engineering and technological knowledge to solve a wide range of rapid manufacturing problems.	L3

COURSE CONTENT:	
MODULE 1: ROLE OF MATERIALS	09Hrs
Choosing Materials for Manufacturing, Multiple Materials, Metal AM Processes & Materials Composite Materials, Biomaterials, Hierarchical Materials & Bio mimetics, Ceramics & Bio-ceramics, Shape-Memory Materials, 4D Printing & Bio-active materials, Discussion on different materials used, multifunctional and graded materials in AM	
MODULE 2: MATERIAL DESIGN & QUALITY ASPECTS	09Hrs
Machines for Additive Manufacturing, Secondary Rapid Prototyping processes, Intellectual Property, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing. Design for AM (Build orientation, Topology optimization, Conformal cooling channels).	
MODULE 3: MATHEMATICAL MODELS IN AM	09Hrs
Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation. Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Model validation for different criteria). Thermal cycle, Single bead and multi bead formation in cladding based AM processes	
MODULE 4: ADDITIVE MANUFACTURING FOR BIO-MEDICAL DEVICES & OTHERS	09Hrs
Bio microfluidics, Tissue Engineering. 3D Printing in Medicine, Computer Aided Design approach, medical research and clinical grade AM materials and AM fabrication methods, Biomedical Applications, Direct Digital Manufacturing, Distributed Manufacturing, Mass Customization, , Aerospace & Automotive Applications, Architectural Engineering, Food & Consumer Applications, Personalized Surgery, Art, Fashion, Jewelry, Toys & Other Applications	
MODULE 5: RAPID MANUFACTURING OBJECTS	06Hrs
RM of polymeric objects, Direct and indirect routes for RM of metallic & ceramic objects, Advancement in RM (Synergistic integration of hybrid processes and multiple technologies). Smart materials.	

TEXT BOOKS:

1. Ian Gibson, David Rosen, and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer, New York, NY, 2015.
2. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

REFERENCES:

4. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007
5. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
6. Duc Pham, S.S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer-Verlag London, 2001.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3607					
TITLE OF THE COURSE	PROCESSING OF PLASTICS & COMPOSITES					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- Elaborate the fundamentals of plastics and polymer composites including their matrix & reinforcement material.
- understand the various processing techniques of plastic materials
- learn the basic knowledge on machining/joining of plastic materials
- Impart different processing techniques of polymer matrix composites.
- provide a wide knowledge on various secondary processing techniques of polymer composites

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand various kinds of plastics and polymer composite materials.	L2
C02	Distinguish various processing methods and its process parameters for different plastics	L2
C03	Interpret the machining/joining properties of different plastics	L3
C04	Demonstrate the various processing techniques of polymer composites along with their parameter and process control	L2
C05	Classify the different secondary processing techniques of polymer composites	L2

COURSE CONTENT:	
MODULE 1: INTRODUCTION TO PLASTICS AND COMPOSITES	08Hrs
Chemistry and Classification of Polymers – Properties of Thermoplastics – Properties of Thermosetting Plastics – Applications – Merits and Disadvantages. Fibres – Glass, Boron, Carbon, Organic, Ceramic and Metallic Fibers – Matrix Materials – Polymers, Metals and Ceramics	
MODULE 2: PROCESSING OF PLASTICS	09Hrs
Extrusion – Injection Moulding – Blow Moulding – Compression and Transfer Moulding – Casting – Thermo Forming. Process parameters, Applications & Limitations	
MODULE 3: MACHINING AND JOINING OF PLASTICS	08Hrs
General Machining properties of plastics – Machining Parameters and their effect – Joining of Plastics – Mechanical Fasteners – Thermal bonding – Press Fitting.	
MODULE 4: PROCESSING OF POLYMER MATRIX COMPOSITES	09Hrs
Open Mould Processes, Spray-layup, Bag Moulding, Compression Moulding with BMC and SMC –Filament winding – Pultrusion – Centrifugal Casting – Injection Moulding – Reaction injection molding, Autoclaving, Resin transfer molding-Application of PMC's.	
MODULE 5: SECONDARY PROCESSING OF POLYMER COMPOSITES	08Hrs
Secondary processing of polymer composites: Joining of polymer composites, Adhesive joining. Mechanical joining, Microwave joining, Induction and resistance welding, Drilling of polymer composites. Conventional vs ultrasonic drilling, Remedies for reducing drilling induce damages, Research tools for secondary processing.	

TEXT BOOKS:

1. A. Brent Strong (2005), Plastics: Materials and Processing, 3rd Edition, Pearson Publications.
2. Frank L. Matthews, R D Rawlings (1999), Composite Materials: Engineering and Science, CRC Press.

REFERENCES:

1. K. K. Chawla (2006), Composite Materials: Science and Engineering, Springer Publications.
2. Akira Kobayashi (1967), Machining of Plastics, 1st edition, McGraw-Hill Publications.
3. Michael L. Berins (1991), SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc., 1st Edition Springer Publications.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3608					
TITLE OF THE COURSE	AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The course will enable the students to:

- To learn the types of chassis and axles.
- To study about the steering system and its methods.
- To understand the suspension systems and its components.
- To learn the functions of universal joint and propeller shafts.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To make students familiar with the constructional details of chassis and body.	L2
CO2	The student will understand the principle and working of the Torque Converters	L2
CO3	The student will know about the Automatic Transmission and Applications of Automatic Transmission	L1
CO4	The student will understand the principle and working of the Hydro-Static Drive and Electric Drives.	L2
CO5	The student will understand the principle and working of the clutch, gearbox	L2

COURSE CONTENT:

MODULE 1 Chassis & Body	08Hrs

Types of chassis layout with reference to power plant locations and drive. Vehicle frames. Various types of frames. Constructional details. Materials. Testing of vehicle frames., Loads acting on vehicle frame. Integrated body construction, BIW types and corresponding design parameters, Vehicle interior system, A, B, & C Pillar.	
MODULE 2 Front Axle And Steering System	08Hrs
Types of front axle. Constructions details. Materials. Front wheel geometry viz. Castor, Camber, King pin inclination, Toe-in. Conditions for true rolling motion of wheels during steering. Steering geometry. Ackerman and Davis steering system. Constructional details of steering linkages. Different types of steering gear boxes. Steering linkages and layouts. Power assisted steering.	
MODULE 3 Clutch and Gear Box	10Hrs
Clutch – function – clutch actuating mechanism – Mechanical and hydraulic types – clutch material – single plate dry clutch – dual plate dry clutch – multi plate wet clutch – semi centrifugal and centrifugal clutch – motor cycle clutch – Diaphragm clutch – fluid coupling and torque converter – Trouble shooting of Clutch. Gear Box – purpose – resistance offered to the motion of the vehicle – air resistance – rolling resistance – Resistance offered to the motion of the vehicle – gradient resistance – tractive effort -gear ratio – types of gear boxes – sliding mesh – constant mesh -synchromesh device – epicyclic – over drive – under drive and transfer cases – 4 wheel drive – gear shifting mechanism – floor shifting and steering column shifting – Automatic Gear box (CVT) -Trouble shooting of gear box.	
MODULE 4 Automatic Transmission systems	08Hrs
Principle of working of epi-cyclic gear train - Construction and working principle of Ford-T model gear box - Wilson gear box- construction, working and derivation of gear ratios - Cotal electromagnetic transmission - Automatic over-drive - Hydraulic control system for automatic transmission. Chevrolet automatic transmission - Turbo glide transmission - Power glide transmission - Toyota “ECT-i” [Automatic transmission with intelligent electronic control systems] - Mercedes Benz automatic transmission - Hydraulic clutch actuation system for automatic transmission	
MODULE 5 Hydro-Static Drive and Electric Drives	08Hrs
Hydrostatic drive – principle, types, advantages, limitations - Comparison of hydrostatic drive with hydrodynamic drive - Construction and working of typical Janny hydrostatic drive. Lay-out of elective drive - Principle of early and modified ward Leonard control systems – advantages, limitations, performance characteristics	

TEXTBOOKS:

1. Tim Gilles, Automotive Chassis-Brakes, Steering and Suspension, Thomson Delmer Learning, 2005.

2. Heldt.P.M, "Automotive Chassis", Chilton Co., New York, June 2012.

REFERENCES:

1. Jornsens Reimpell, Helmut Stoll, Automotive Chassis: Engineering Principles, Elsevier, 2nd edition, 2001.
2. Crouse.W.H, Automotive Chassis and Body, McGraw Hill New York, 1971.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3610					
TITLE OF THE COURSE	RENEWABLE ENERGY SOURCES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The course will enable the students to:

- To educate the students scientifically the new developments in renewable energy studies
- To make understand the new developments in non-conventional and renewable energy studies.
- To emphasize the significance of Green Energy Technologies

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To understand importance of solar energy applications	L1
CO2	To know the principles of power generation by wind energy	L2
CO3	To know ocean energy technologies to harness power	L2

C04	To appreciate the use of hydrogen as renewable energy source	L3
C05	Develop capability to do basic design of bio gas plant	L2

COURSE CONTENT:	
MODULE 1 Solar Energy	10 Hrs
Solar Energy- Solar radiation its measurements and prediction - solar thermal collectors - flat plate collectors, concentrating collectors – applications - heating, cooling, desalination, drying, cooking, etc. Principle of photovoltaic conversion of solar energy - types of solar cells and fabrication -photovoltaic applications - battery charging, domestic lighting, street lighting.	
MODULE 2 Wind Energy	08 Hrs
Wind Energy- Wind energy - energy chains - application - historical background, merits and limitations - nature of wind - planetary and local day / night winds - wind energy quantum - power in wind- turbine efficiency - torque thrust calculations - velocity at different heights - site selection - components of wind energy conversion system (WECS).	
MODULE 3 Energy from Biomass	08 Hrs
Energy from biomass - biomass as renewable energy source - types of bio mass fuels - solid, liquid and gas - biomass conversion techniques- wet process, dry process photosynthesis - biogas generation - factors affecting bio- digestion - classification of bio gas plant - continuous, batch and fixed dome types - advantages and disadvantages	
MODULE 4 Tidal, Ocean Thermal Energy, Hydel and Geothermal Energy Conversion	08 Hrs
Tidal Energy: tide – spring tide, neap tide – tidal range – tidal power – types of tidal power plant – single and dual basin schemes – requirements in tidal power plant - ocean thermal energy conversion (OTEC): principle - open and closed OTEC cycles - hydel energy: micro hydro - geothermal energy: geothermal energy sources - power plant and environmental issues.	
MODULE 5 New Energy Sources	08 Hrs
Hydrogen as a renewable energy source - sources of hydrogen - fuel for vehicles - hydrogen production - direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production - storage of	

hydrogen - gaseous, cryogenic and metal hydride - fuel cell – principle of working, construction and applications

TEXTBOOKS:

1. Rai.G.D, Non- conventional resources of energy, Khanna publishers, Fourth edition, 2010.
2. Khan. B.H, Non-Conventional Energy Resources, McGraw Hill, Second edition, 2009.

REFERENCES:

1. Rao.S & Parulekar, Energy Technology, Khanna publishers, Fourth edition, 2005.
2. Pai.B.R and Ram Prasad.M.S, Power Generation through Renewable Sources of Energy, Tata McGraw Hill, New Delhi, 1991.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3611					
TITLE OF THE COURSE	PRODUCT DESIGN AND MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES :

- To expose the students the basics of product design and manufacturing
- To introduce students to the basic principles and evaluation methods of various aspects of designing components
- To teach students about the Industrial manufacturability requirements
- To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyse the product life cycle phases of any product and suggest appropriate strategies	L2
CO2	Construct product planning and specification documents	L3
CO3	Demonstrate the knowledge of Architectural and Industrial design aspects of product design	L3
CO4	Apply design for excellence (DF-X) concepts in product design	L3
CO5	Choose an appropriate manufacturing process for product prototyping.	L4

COURSE CONTENT:	
MODULE 1	08Hrs
Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry -Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies.	
MODULE 2	08Hrs
Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD) Product Specifications: specifications, specifications established, establishing target specifications, setting the final specifications, Case Studies.	
MODULE 3	08Hrs
Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies.	
MODULE 4	08Hrs
Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality) Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design,	

Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies.	
MODULE 5	08Hrs
Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereolithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies.	
TEXT BOOKS: 1. A C Chitale and R C Gupta, Product Design and Manufacturing -, PH1, - 3rd Edition, 2003 REFERENCES: 1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development - McGraw Hill -2000 2. Tim Jones, Butterworth Heinmann, New Product Development - Oxford. UCI - 1997 3. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002	

PROGRAM ELECTIVE – III

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36112					
TITLE OF THE COURSE	ROBOT KINEMATICS AND DYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES :

- To introduce to the control position and orientation of the tool in the three dimensional space.
- To make the student familiar with the joint variables and the position and the orientation of the tool.
- To discuss about creating paths for the tool to follow in order to do useful tasks
- To properly regulate the system's high-speed motion.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To control both the position and orientation of the tool in the three dimensional space.	L2
CO2	The relationship between the joint variables and the position and the orientation of the tool.	L2
CO3	Planning trajectories for the tool to follow on order to perform meaningful tasks.	L3
CO4	To precisely control the high speed motion of the system.	L3
CO5		L3

COURSE CONTENT:

MODULE 1-INTRODUCTION	10Hrs
Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.	
MODULE 2 DIRECT KINEMATICS	08Hrs

Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.	
MODULE 3 INVERSE KINEMATICS	08Hrs
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.	
MODULE 4 WORKSPACE ANALYSIS AND TRACJECTORY PLANNING	08Hrs
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique -continuous path motion, Interpolated motion, straight line motion and Cartesian space teclnique in trajectory planning.	
MODULE 5 MANIPULATOR DYNAMICS	08Hrs
Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange Euler formulation, problems.	

TEXT BOOKS :

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Me Graw Hill Publishing company Ltd., 1995.

REFERENCES :

1. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
2. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house, 1993.
3. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, MIT Press, 2003.
4. John J. Craig, Introduction to Robotics Mechanics and Control, Third Edition, Pearson, 2008.
5. Bijay K. Ghosh, Ning Xi, T.J. Tam, Control in Robtics and Automation Sensor -Based integration, Academic Press, 1999.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36114					
TITLE OF THE COURSE	COMPUTATIONAL TOOLS FOR ADDITIVE MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	48	3

COURSE OBJECTIVES:

- The primary objective of the course is to give students both a practical and a theoretical knowledge of every stage in the additive manufacturing.
- To provide a broad overview of both hardware and software for additive manufacturing
- To introduce to methods for parametric modeling of solid objects that take into account fabrication constraints.
- To cover optimization methods that are applied to automate the design process and additive manufacturing process.
- To cover latest research work in the field of computational fabrication

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to understand and use fundamental computer graphics in the context of design and additive manufacturing	L2
CO2	Students will be able to develop geometric models both parametric and organic using computational geometry techniques	L3
CO3	Students will be able to analyze many instances of recent computational fabrication systems that seamlessly blend parametric modeling, slicing and optimization	L3
CO4	In the second part of the semester, students work in groups on large open-ended projects	L1
CO5	Students will be introduced to case studies of latest research papers in the field of additive manufacturing	L2

COURSE CONTENT:

MODULE 1	08 Hrs
Object Transformations: Object Translation, Object Scaling, Object Rotation, Object Reflection, Object Scaling module	
MODULE 2 Geometric Modeling	08 Hrs
Hermite Curve Design, Hermite Surface Design, Bezier Curve Design, Bezier Surface Design, B-Spline Curve Design, B-Spline Surface Design, Parametric Design	
MODULE 3 Computational geometry	10 Hrs
Convex Hulls: Convexity, The Incremental Algorithm, Analysis of Algorithms, Gift	

Wrapping and Graham Scan, Lower Bound, Divide-and-Conquer; Polygons: Diagonals and Triangulations, Tetrahedralizations, Basic Combinatorics, The Art Gallery Theorem, Scissors Congruence in 2D, Scissors Congruence in 3D; Triangulations: Point Sets, Basic Constructions, Delaunay Triangulations; Voronoi Diagram

MODULE 4 Optimization Methods

08 Hrs

Optimization methods for preprocessing and post processing analysis of geometric models for additive process friendly part builds

MODULE 5

08 Hrs

Case Studies from latest research papers

TEXTBOOKS:

1. Zeid, I. (1991). CAD/CAM theory and practice. McGraw-Hill Higher Education.
- 2.

REFERENCES:

1. Kieran, Stephen, and James Timberlake. Refabricating Architecture: How Manufacturing Methodologies are Poised to Transform Building Construction. New York, NY: McGraw-Hill, 2003. ISBN: 9780071433211.
2. Schodek, Daniel, et al. Digital Design and Manufacturing: CAD/CAM Applications in Architecture and Design. New York, NY: John Wiley & Sons, 2004. ISBN: 9780471456360.
3. Schwalbe, M., 2016. Predictive Theoretical and Computational Approaches for Additive Manufacturing: Proceedings of a Workshop.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36116					
TITLE OF THE COURSE	HEV / EV SYSTEM DESIGN ARCHITECTURE					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	0	0	-	42	3

COURSE OBJECTIVES:

The course will enable the students to:

- Explain the basics of electric and hybrid electric vehicles, their architecture
- Explain hybrid electric vehicle architecture, design and component sizing in hybrid

electric vehicles.

- Analyze various electric drives suitable for hybrid electric vehicles
- Demonstrate different configurations of electric vehicles and its components.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Students will be able to Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals	L1
C02	Analyse the use of different power electronics devices and electrical machines in hybrid electric vehicles	L3
C03	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	L1
C04	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis	L2
C05	Understand Energy Management strategies in HEVs	L1

COURSE CONTENT:

MODULE 1 Design & Engineering – xEV	08 Hrs
xEV : micro to mild to PHEV to HEV to REEV to EV - Hybrid-Electric Vehicle Power trains - Vehicle Energy Storage System (VESS) Design - Computational Systems Design (CSD) - Transportation Electrification	
MODULE 2 Introduction to Advanced Electric Vehicles	08 Hrs
Fundamentals of xEVs and key challenges and opportunities of AEV technologies - Engineering philosophy of various xEVs (HEV, PHEV and BEV, REEV)	
MODULE 3 Energy Storage Systems	08 Hrs
Energy storage systems used; Battery electro-chemistry, battery design and	

construction, charging and discharging, power density, Battery interface with motive source	
MODULE 4 Power Electronics for Electric Vehicles & Energy Conversion	08 Hrs
Power electronics including switching, AC-DC, AC-AC conversion, electronic devices and circuits used for control and distribution of electric power Electric Drives / Electromechanical Motors & motive power splitting concepts, and interface within power train system	
MODULE 5 Hybrid Electrical Vehicles	10 Hrs
Introduction - System Overview - Power train architecture - Parallel, Series and Combined - Types of xEVs - Vehicle layout and packaging options. - Energy devices & combinations - examples & Case Studies - Environmental Impact - Regulatory Issues (CO ₂ gas and particulate emissions) - Duty Cycles in Indian cities; performance (off cycle, durability) - Sustainability assessment; cradle to grave environmental impact.	

TEXTBOOKS:

1. Iqbal Husain, "Electric and Hybrid Vehicles –Design Fundamentals", CRC Press
2. Mehrdad Ehsani, Yimin Gao, Sebastian E.Gsay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell vehicles-Fundamentals - Theory and Design", CRC Press

REFERENCES:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 2003
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36117					
TITLE OF THE COURSE	MATERIALS AND MANUFACTURING PROCESSES FOR AUTOMOTIVE SYSTEMS					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- To develop the knowledge of the properties of materials and its alloys
- To introduce the modern materials and alloys.
- To introduce the Surface modification of materials

- To develop knowledge in recent trends in manufacturing techniques of automobile components

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand various materials and its alloys are formed and their classification based on atomic arrangement	L2
C02	Describe the mechanical behavior of metallic systems and its importance	L3
C03	Understand the need for modern materials and its alloys.	L3
C04	Gain knowledge on different class of materials, alloys and their manufacturing techniques, applications in automobile field.	L4
C05	Understand the need for Recent Trends in manufacturing Auto components.	L2

COURSE CONTENT:

MODULE 1: Engineering alloys

08Hrs

Ferrous alloys-Iron-Iron carbide phase diagram with all phases & critical temperatures-**steel**, Types of steels-Effect of alloying elements on physical and chemical properties-**Automotive applications**- cast iron-Types-properties-factors affecting structures of cast iron-Automotive application.

Non ferrous alloys- Al, Cu, Tin, Baased alloys, Light metal alloys(mg and Ti)

MODULE 2: Surface modification of materials

08Hrs

Mechanical surface treatment and coating- case hardening and hard facing-thermal spraying-Vapor deposition-ion implantation-diffusion coating-Electroplating and Electro less plating-Conversion coating-Ceramic and Organic coating-Diamond coating-Laser surface treatment-Selection of coating for Automotive applications

MODULE 3: Modern materials and alloys

10Hrs

Super alloys-super plastic alloys for auto body panels-refractory metals-shape memory alloys-dual phase steels-micro alloyed steels-high strength low alloy steels-smart materials -**Composite materials-ceramic** -plastics-introduction, overview of processing, their characteristic features, Types and automotive application-Nanomaterials-Introduction and automotive applications

08Hrs

MODULE 4: Engine materials and manufacturing

Cylinder block and head-cylinder head and gasket-valves, seats and guides-piston and pin-piston ring and liner-con rod-crankshaft and bearing-turbocharger.

Case study: Engine materials used in 4stroke, 2stroke petrol and diesel engine.

MODULE 5: Recent Trends in manufacturing Auto components	08Hrs
Special processing techniques -Hydroforming-stretch forming-Recent developments in auto body panel forming-squeeze casting of pistons, Aluminium composite brake rotors-sinter diffusing bonded idler sprocket-Gas injection moulding of window channel-Cast con process for auto parts-computer modeling and simulation-material characteristics and failure analysis.	

TEXT BOOKS:

1. Callister W.D. (2006) "Material Science and Engineering- An introduction", Wiley –Eastern
2. Flinn R. A. and Trojan P. K., (1999)"Engineering Materials and their Applications", Jaico.

REFERENCES:

1. Avner S.H., (2006) "Introduction to physical metallurgy" –Tata McGraw Hill..
2. Haslehurst.S.E., " Manufacturing Technology ", ELBS, London, 1990

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36118					
TITLE OF THE COURSE	INTERNAL COMBUSTION ENGINES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	48	3

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The course will enable the students to:

- To get familiar with the fundamentals of I.C engines, construction and working principle of an engine, and testing of an engine for analysing its performance.
- To study the combustion and its controlling factors in order to design efficient engine
- To study emissions from internal combustion engines and its controlling methods, various emission norms.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student will be able to analyse thermodynamic cycles based on actual conditions.	L3
CO2	Understand operating characteristics of different engine and combustion process for SI and CI engines.	L1
CO3	Understand the different combustion chamber designs and compare for different types fuels used.	L1
CO4	Analyze the emissions in combustion	L3
CO5	Understanding of the various heat transfer mechanisms in the engine	L1

COURSE CONTENT:**MODULE 1 Basics of Internal Combustion Engines****08 Hrs**

Heat engine, internal combustion engines and external combustion engines, internal combustion engine construction - components and materials, engine nomenclature, valve timing diagram, intake and exhaust system, engine classification, applications. Fuel air cycle and actual cycle: fuel air cycle, assumptions, comparison with air standard cycle, effect of variables on performance, actual cycle and various losses.

MODULE 2 Spark Ignition Engines**08Hrs**

Theory of carburetion, types of carburetors, electronic fuel injection system, combustion in spark ignition engines, stages of combustion, flame propagation, rate of pressure rise, abnormal combustion, phenomenon of detonation in spark ignition engines, effect of engine variables on detonation. Combustion chambers, rating of fuels in spark ignition engines, additives.

MODULE 3 Compression Ignition Engines**08 Hrs**

Fuel supply system, types of fuel pump, injector and distribution system, combustion in compression ignition engines, stages of combustion, factors affecting combustion, phenomenon of knocking in compression ignition engine. Effect of knocking, methods of knock control, types of combustion chambers, rating of fuels in compression ignition engines. Dopes & additives, comparison of knocking in spark ignition & compression ignition engines.

MODULE 4 Combustion Chambers	08 Hrs
Requirements of combustion chambers, features of different types of combustion chambers system for S.I. engine. I-head, F-head combustion chambers. C.I. engine combustion chambers-air swirl turbulence, M-type combustion chamber. Comparison of various types of combustion chambers.	
MODULE 5 Internal Combustion Engine-System, Emission and Control	10 Hrs
Internal combustion, Engine Systems: Cooling system, lubrication system, ignition system, governing system, starting system. Internal combustion engine emissions and control air pollution due to internal combustion engine and its effect, emissions from petrol/gas and diesel engines, sources of emissions, euro norms, Bharat stage norms, emission control methods for spark ignition and compression ignition engines.	

TEXTBOOKS:

1. M. L. Mathur and R. P. Sharma , A course in I.C. Engines, , Dhanpat Rai Pub, 2001.
2. Colin R. Ferguson C, Internal Combustion Engines, John Wiley & sons, 1986

REFERENCES:

1. Heywood, Internal Combustion Engine Fundamentals, Tata McGraw-Hill, 2011
2. V. Ganesan, Internal Combustion Engines, Tata McGraw-Hill, 2012

OPEN ELECTIVE - I

SEMESTER	V					
YEAR	III					
COURSE CODE	200E0015					
TITLE OF THE COURSE	AUTOMOBILE ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To understand basics of Automobile Engineering & various automotive system.
- To understand vehicle layout, vehicle specifications & important of automobile.
- To make the student conversant with drive train & transmission.
- Understand the various Automobile Electrical System, Vehicle performance & their safety

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain components of automotive vehicle	L1
C02	Describe functioning of automotive transmission system	L1
C03	Calculate the resistance offered to the automobile by various factors	L2
C04	Describe various electrical components used in automobiles	L1
C05	Diagnosis the faults of automobile vehicles.	L2

COURSE CONTENT:	
MODULE 1	08Hrs s

Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.

MODULE 1	08Hrs
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	
MODULE 2	08Hrs
Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission, Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive.	
MODULE 3	10Hrs
Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. Suspension: Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), damping and shock absorbers Brakes: Types of brake systems - drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.	
MODULE 4	08Hrs
Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise.	
MODULE 5	08Hrs
Batteries: Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods. Lighting System & Accessories: Insulated & earth return systems, positive & negative earth systems, electrical fuel pump, speedometer, fuel, oil & temperature gauges, horn, wiper system, trafficator, sensors and actuators, electronic control unit, traction control devices. Vehicle maintenance Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system.	

TEXT BOOKS :

1. William H. Crouse., "Automotive Mechanics", Tata McGraw Hill Publishing House.

REFERENCES :

1. K. Newton and W. Seeds, T.K. Garrett, "Motor Vehicle", 13th Edition, Elsevier publications
2. Hans Hermann Braess, Ulrich Seiffen, "Handbook of Automotive Engineering ", SAE Publications

SEMESTER	V					
YEAR	III					
COURSE CODE	200E0016					
TITLE OF THE COURSE	RAPID MANUFACTURING TECHNOLOGIES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To provide knowledge of methods for the manufacturing of prototypes from computer based models
- To understand the entire process of direct manufacturing from the creation of computer based models to their physical realization
- To understand the various methods of manufacturing and their merits, demerits and applications
- To impart students to convert CAD models into real life engineering components

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the various rapid prototyping technologies ,	L1
C02	Select appropriate technology for product development	L2
C03	Describe rapid prototyping techniques	L1
C04	Analyse the quality of a product using rapid prototyping technique	L3
C05	Describe application of rapid prototyping	L1

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction- Need for the compression in product development, Historical development, Fundamentals of RP, Advantages and Classification of RP systems. Process chain, RP Data	

Formats, Information flow in an RP system.	
MODULE 2	10Hrs
Stereo lithography Apparatus (SLA): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Solid ground curing (SGC): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications.	
MODULE 3	10Hrs
Fused Deposition Modelling (FDM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Laminated Object Manufacturing (LOM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Ballistic Particle Manufacturing (BPM): Principle.	
MODULE 4	10Hrs
Selective laser sintering (SLS): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Three dimensional Printing (3DP): Principle, process parameters, process details, machine details, products, Advantages, Limitations, applications. Laser Engineering Net Shaping (LENS) - Principle. Concept modellers like thermal jet printers, Sander's model maker, GenisysXs 3D printers, JP system 5, Object Quadra system.	
MODULE 5	10Hrs
Introduction to rapid tooling: Direct soft tooling- casting molds, Direct AIM, composite tooling. Indirect soft tooling- spray metal molding, silicon rubber molds, Castable resin and ceramic molds. Direct hard tooling-rapid tool, Laminated metal tooling, DMLS tooling. Indirect hard tooling- 3D keltool, ED electrodes, Ecotool, copy milling. Applications: Application-Material Relationship, Applications in Design, Applications in Engineering, Analysis and Planning. Application of Rapid prototyping in biomedical, automotive, aerospace, jewellery and coin industries.	

TEXT BOOKS :

1. C. K.Chua, K. F.Leong and C. S.Lim, Rapid prototyping: Principles and applications, World Scientific Publishers, 2003

REFERENCES :

1. Andreas Gebhardt, Hanser , Rapid prototyping, Gardener Publications, 2003.
2. L.W.Liou, F.W. Liou, Rapid Prototyping and Engineering applications: A tool box for prototype development,

OPEN ELECTIVE – II

SEMESTER	VI					
YEAR	III					
COURSE CODE	200E0017					
TITLE OF THE COURSE	ROBOTICS ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To introduce the basic concepts, parts and types of robots.
- To make the student familiar with the various sensors, drive systems in robots and programming.
- To discuss about the various applications, justification and implementation of robot.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic principles of Robotic technology, configurations, control and programming of Robots	L2
C02	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
C03	To choose the appropriate Sensor and Machine vision system for a given application	L3
C04	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
C05	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material	

transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	08Hrs
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	08Hrs
Drive system, control system, robot drive mechanisms, hydraulic - electric - servomotor- stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	08Hrs
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	08Hrs
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS :

1. AshitavaGhosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES :

1. Fu, K. S, Gonzalez, R. C, Lee, C.S.G, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987
2. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	VI					
YEAR	III					
COURSE CODE	200E0018					
TITLE OF THE COURSE	PRODUCT DESIGN AND MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To expose the students the basics of product design and manufacturing.
- To introduce students to the basic principles and evaluation methods of various aspects of designing components.
- To teach students about the Industrial manufacturability requirements.
- To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Analyse the product life cycle phases of any product and suggest appropriate strategies	L2
C02	Construct product planning and specification documents	L3
C03	Demonstrate the knowledge of Architectural and Industrial design aspects of product design	L3
C04	Apply design for excellence (DF-X) concepts in product design	L3
C05	Choose an appropriate manufacturing process for product prototyping.	L4

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry -Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies	

MODULE 2	08Hrs
Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD) Product Specifications: specifications, specifications established, establishing target specifications, setting the final specifications, Case Studies	
MODULE 3	08Hrs
Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies	
MODULE 4	08Hrs
Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies	
MODULE 5	08Hrs
Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereolithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies.	

TEXT BOOKS :

1. A C Chitale and R C Gupta, Product Design and Manufacturing -, PH1, - 3rd Edition, 2003

REFERENCES :

1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development - McGraw Hill -2000.
2. Tim Jones, Butterworth Heinmann, New Product Development - Oxford. UCI - 1997
3. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002
3. J.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4701					
TITLE OF THE COURSE	CONTROL SYSTEMS ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	65	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- Gain a thorough understanding of the principles and theories behind control systems.
- Develop the ability to analyze control systems in both the time and frequency domains.
- Acquire skills to design and tune controllers to meet specific performance requirements.
- Master the state space analysis method for a better understanding of control system characteristics.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply fundamental control theory principles to model complex mechanical systems using transfer functions and state-space methods.	L3
CO2	Implement time and frequency domain techniques to analyze the stability and performance of control systems.	L4
CO3	Design and tune controllers, such as PID controllers and compensators, to enhance system performance and stability.	L3
CO4	Apply root locus and frequency domain methods for the design and tuning of control systems.	L3
CO5	Implement state space analysis to determine system controllability, observability, and stability.	L4
CO6	Use computer software tools, such as MATLAB or Simulink, to simulate and analyze the behavior of control systems.	L3

COURSE CONTENT:	
MODULE 1	07Hrs
Introduction to Control Systems includes basics of control systems, differentiation between open loop and closed loop systems, system modeling using transfer functions and state space, along with block diagrams and signal flow graphs.	
MODULE 2	08Hrs

Time Domain Analysis introduces standard test signals, time response of first and second order systems, time domain specifications, steady-state errors, and stability analysis using the Routh-Hurwitz Criterion.	
MODULE 3	08Hrs
Frequency Domain Analysis consists of understanding the correlation between time and frequency response, usage of Bode and Nyquist plots, and stability analysis in the frequency domain through the Nyquist Criterion, gain and phase margins.	
MODULE 4	08Hrs
Design of Control Systems focuses on learning compensation techniques such as lead, lag, and lead-lag compensators, design of PID controllers, root locus technique, and frequency domain design with design specifications and performance indices.	
MODULE 5	08Hrs
State Space Analysis entails learning about the concept of state, state variables, state model, solutions to state equations, controllability, observability, pole placement design, and quadratic optimal control systems.	

Lab Component (26 hours):

Lab 1: Introduction to Control Systems - 4 hours

Software-based simulation to understand the basics of open and closed-loop control systems. Understanding transfer function and state-space representation of systems through modeling.

Lab 2: Time Domain Analysis - 5 hours

Experimental study of the response of first and second-order systems for standard test signals. Implementing Routh-Hurwitz criterion to determine system stability.

Lab 3: Frequency Domain Analysis - 5 hours

Plotting and interpreting Bode and Nyquist plots. Applying Nyquist criterion to analyze system stability.

Lab 4: Design of Control Systems - 6 hours

Designing and tuning of a PID controller for a given system. Use of root locus method for system design.

Lab 5: State Space Analysis - 6 hours

Conducting state-space analysis for control systems. Observability and controllability analysis for given systems.

Textbooks:

- Nise, N. S., "Control Systems Engineering", 8th Edition, Wiley, 2019.
- Ogata, K., "Modern Control Engineering", 5th Edition, Prentice Hall, 2009.

References:

- Dorf, R. C., and Bishop, R. H., "Modern Control Systems", 13th Edition, Pearson, 2016.
- Franklin, G. F., Powell, J. D., and Emami-Naeini, A., "Feedback Control of Dynamic Systems", 8th Edition, Pearson, 2019.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4703					
TITLE OF THE COURSE	INDUSTRIAL AUTOMATION – II					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

1. To deepen students' understanding of the role of advanced Industrial IoT (IIoT) systems in industrial automation.
2. To develop proficiency in integrating vision systems and sensors into automation processes for improved efficacy.
3. To provide a detailed understanding of advanced robotics, machine learning, and AI applications in the realm of industrial automation.
4. To familiarize students with the principles of Industry 4.0, digital twin technology, and their significance in the digital transformation of manufacturing.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Implement advanced Industrial IoT (IIoT) concepts, including cloud and edge computing solutions, in modern industrial automation setups.	L4
CO2	Use knowledge of vision systems and sensors to analyze their role and effectiveness in automation processes.	L3
CO3	Apply principles of advanced robotics, including robot kinematics, dynamics, trajectory planning, and multi-robot systems, to enhance automation efficiency.	L3
CO4	Develop machine learning models to solve automation problems and use artificial intelligence techniques to optimize industrial processes.	L4

CO5	Assess the implications of Industry 4.0 principles and digital twin technology in the digital transformation of manufacturing.	L3
CO6	Utilize advanced simulation and modeling techniques to design and improve automated systems.	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Advanced Industrial IoT (IIoT): exploration into Industrial IoT (IIoT) applications in modern industrial automation, including cloud computing, edge computing, cybersecurity in IIoT, and advanced analytics and machine learning for predictive maintenance and quality control.	
MODULE 2	08Hrs
Vision Systems and Sensors in Automation: Introduction to the role of vision systems and sensors in automation. Topics include machine vision, sensor integration with automation systems, data acquisition, and sensor fusion.	
MODULE 3	08Hrs
Advanced Robotics: advanced topics in robotics, including robot kinematics, dynamics, and trajectory planning. The module also covers AI integration in robotics, multi-robot systems, and swarm robotics.	
MODULE 4	07Hrs
Machine Learning and AI in Industrial Automation: application of machine learning and artificial intelligence in industrial automation. Topics include predictive modeling, neural networks and AI-driven optimization of manufacturing processes.	
MODULE 5	08Hrs
Industry 4.0 and Digital Twin Technology: This module focuses on the principles of Industry 4.0, the digital transformation of manufacturing, and the application of digital twin technology in product lifecycle management.	

Textbooks:

Maynard, H. B., "Maynard's Industrial Engineering Handbook", 5th Edition, McGraw-Hill, 2001.

Craig, J.J., "Introduction to Robotics: Mechanics and Control", 4th Edition, Pearson, 2017.

References:

Esposito, A., "Artificial Intelligence and Robotics", Springer, 2020.

Sikora, R., "Industry 4.0: Industrial Revolution of the 21st Century", Springer, 2019.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4704					
TITLE OF THE COURSE	AUTOMATION SYSTEM DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To provide students with a comprehensive understanding of the principles of automation system design.
- To develop skills in designing efficient automated manufacturing systems and implementing material handling and storage solutions.
- To familiarize students with the application of control systems like PLCs, DCS, and SCADA in automation.
- To equip students with the knowledge of simulation techniques and optimization methods for enhancing the efficiency and productivity of automated systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply the fundamental concepts of automation system design to develop efficient automated solutions.	L3
CO2	Design automated manufacturing systems, including work cells and assembly lines, while considering factors like assembly, testing, and inspection.	L4
CO3	Utilize different types of material handling and storage systems, including automated guided vehicles, conveyors, and automated storage and retrieval systems.	L3
CO4	Implement control systems like programmable logic controllers (PLCs), Distributed Control Systems (DCS), and Supervisory Control and Data Acquisition (SCADA) in automation system design.	L4
CO5	Use simulation techniques effectively for understanding the behavior of automated systems.	L3
CO6	Apply optimization methods to improve the efficiency and productivity of automated systems.	L3

COURSE CONTENT:

MODULE 1	08Hrs
Fundamentals of Automation System Design delves into the basic concepts of automation, system design, and life cycle. This module also provides an overview of different types of automation systems such as fixed, programmable, and flexible systems.	
MODULE 2	08Hrs
Design of Automated Manufacturing Systems, students learn about the concepts of production system design, work cells, assembly lines, and the design strategies for automated assembly, testing, and inspection.	
MODULE 3	08Hrs
Material Handling and Storage Systems covers various types of material handling and storage systems, including the use of automated guided vehicles, conveyors, and automated storage and retrieval systems in modern manufacturing.	
MODULE 4	07Hrs
Control Systems and PLCs delves into the role of control systems in automation. Here, students gain knowledge on programmable logic controllers (PLCs), Distributed Control Systems (DCS), and Supervisory Control and Data Acquisition (SCADA) systems.	
MODULE 5	08Hrs
Simulation and Optimization of Automated Systems introduces students to various simulation techniques for automated systems, and the methods to optimize these systems for better efficiency and productivity.	

Textbooks:

Groover, M. P., "Automation, Production Systems, and Computer-Integrated Manufacturing", 4th Edition, Prentice Hall, 2014.

Bolton, W., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 6th Edition, Pearson, 2015.

References:

Harris, C. M., "Handbook of Automation, Computation, and Control", Volume 2: Systems and Components, 2013.

Shelly, G. B., and Rosenblatt, H. J., "Systems Analysis and Design", 10th Edition, Cengage Learning, 2014. (Useful for its content on system design methodologies and practices)

SEMESTER	VII

YEAR	IV					
COURSE CODE	20ME4705					
TITLE OF THE COURSE	INDUSTRY 4.0 and IOT					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To provide students with an in-depth understanding of Industry 4.0 and IoT and their transformative impact on the industrial sector.
- To develop practical skills in using key IIoT technologies and implementing cyber-physical systems and digital twin technology.
- To equip students with knowledge in data analytics, machine learning, and AI, and their applications in Industry 4.0.
- To cultivate awareness of cybersecurity challenges in Industry 4.0 and strategies to mitigate potential risks.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply the concepts of Industry 4.0 and Internet of Things (IoT) to understand and address industrial challenges.	L3
CO2	Utilize key Industrial IoT (IIoT) technologies such as sensors, actuators, embedded systems, and wireless communication in industrial settings.	L4
CO3	Design and implement cyber-physical systems and digital twin technology in industry-related projects.	L3
CO4	Leverage data analytics, machine learning, and AI to solve complex industrial problems and optimize manufacturing processes.	L4
CO5	Identify common cybersecurity threats in Industry 4.0 and propose strategies to protect industrial systems.	L3
CO6	Analyze and evaluate the impact of Industry 4.0 and IoT on the future of manufacturing and industrial operations.	L3

COURSE CONTENT:	
MODULE 1	08Hrs

Introduction to Industry 4.0 and IoT gives a comprehensive overview of the key concepts and technologies driving Industry 4.0 and Internet of Things (IoT). Topics include the evolution of the industrial revolution, principles of Industry 4.0, the role of IoT in the industry, and an introduction to Industrial IoT (IIoT).	
MODULE 2	08Hrs
IIoT Technologies covers the critical technologies in IIoT, such as sensors and actuators, embedded systems, wireless communication, cloud computing, edge computing, and data analytics.	
MODULE 3	08Hrs
Cyber-Physical Systems and Digital Twin Technology introduces students to the principles of cyber-physical systems and digital twin technology. This module includes the design, implementation, and applications of these systems in the industry.	
MODULE 4	07Hrs
Data Analytics and AI in Industry 4.0 delves into the role of data analytics and AI in Industry 4.0. It covers topics such as predictive analytics, machine learning, and AI-driven optimization in manufacturing.	
MODULE 5	08Hrs
Cybersecurity in Industry 4.0 concludes the course by addressing the critical aspect of cybersecurity in Industry 4.0. It provides an understanding of common security threats, vulnerabilities, and strategies to protect industrial systems.	

Textbooks:

Lu, Y., "Industry 4.0: A Survey on Technologies, Applications and Open Research Issues", Journal of Industrial Information Integration, 2017.

Greengard, S., "The Internet of Things", The MIT Press Essential Knowledge Series, 2015.

References:

Hermann, M., Pentek, T., and Otto, B., "Design Principles for Industrie 4.0 Scenarios, 2016.

Vermesan, O., and Friess, P., "Internet of Things: From Research and Innovation to Market Deployment", River Publishers, 2014.

SEMESTER	VII
YEAR	IV
COURSE CODE	20ME4706

TITLE OF THE COURSE	CAD/CAM for AM					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To introduce students to the principles of CAD/CAM in the context of additive manufacturing and guide them towards mastering these tools.
- To enhance practical skills in designing 3D models using advanced CAD techniques suitable for additive manufacturing processes.
- To equip students with the ability to plan and execute CAM processes, as well as to carry out post-processing and validation of printed parts.
- To facilitate an understanding of the applications of additive manufacturing across industries and to analyze real-world case studies effectively.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply fundamental and advanced CAD/CAM concepts in the context of additive manufacturing.	L3
CO2	Utilize advanced CAD techniques to design complex 3D models tailored for additive manufacturing processes.	L4
CO3	Plan and execute CAM processes for additive manufacturing, including toolpath generation, process parameter selection, and slicing algorithms.	L3
CO4	Implement post-processing methods in additive manufacturing and validate the quality of printed parts through non-destructive testing, dimensional inspection, and mechanical testing.	L4
CO5	Understand and apply the principles of additive manufacturing in various industrial applications.	L3
CO6	Analyze and critique real-world case studies where CAD/CAM is effectively used in additive manufacturing scenarios.	L3

COURSE CONTENT:	
MODULE 1	08Hrs

Introduction to CAD/CAM and Additive Manufacturing introduces the fundamental concepts of CAD/CAM, additive manufacturing technologies, and the role of CAD/CAM in the additive manufacturing process.	
MODULE 2	08Hrs
Advanced CAD Design for Additive Manufacturing covers advanced CAD techniques including 3D modeling, assemblies, and designing for additive manufacturing, with considerations for part orientation, support structures, and material usage.	
MODULE 3	08Hrs
CAM and Process Planning for Additive Manufacturing discusses topics such as toolpath generation, process parameters, slicing algorithms, and build strategies in the context of additive manufacturing.	
MODULE 4	07Hrs
Post-processing and Validation in Additive Manufacturing covers post-processing methods in additive manufacturing, as well as the techniques for validating the printed parts such as non-destructive testing, dimensional inspection, and mechanical testing.	
MODULE 5	08Hrs
Applications and Case Studies in Additive Manufacturing concludes the course by exploring various applications of additive manufacturing in different industries, followed by case studies where CAD/CAM is used effectively in additive manufacturing scenarios.	

Textbooks:

Gibson, I., Rosen, D.W., and Stucker, B., "Additive Manufacturing Technologies", Springer, 2015.

Zeid, I., "Mastering CAD/CAM", McGraw-Hill, 2004.

References:

Wong, K. V., and Hernandez, A., "A Review of Additive Manufacturing", ISRN Mechanical Engineering, 2012.

Bártolo, P. J., "Stereolithography: Materials, Processes and Applications", Springer, 2011.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4707					
TITLE OF THE COURSE	VEHICLE DYNAMICS AND ADVANCED POWERTRAIN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To equip students with a comprehensive understanding of vehicle dynamics and the principles of powertrain systems.
- To develop practical skills in vehicle ride comfort and handling through the study of suspension systems and stability controls.
- To provide insights into advanced powertrain technologies and their implementation in modern vehicle design.
- To foster an understanding of powertrain integration and its effects on vehicle performance, emissions, and fuel economy, promoting sustainable practices in automotive engineering.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply fundamental principles of vehicle dynamics to analyze and address real-world problems related to forces, moments, tire dynamics, and vehicle motion.	L3
CO2	Implement concepts of vehicle ride comfort and handling in the design and improvement of suspension systems and vehicle stability controls.	L4
CO3	Design and optimize powertrain systems by considering the role of various components in vehicle performance.	L3
CO4	Incorporate advanced powertrain technologies such as hybrid and electric powertrains, fuel cell technologies, and energy storage systems into vehicle designs.	L4
CO5	Develop strategies for the integration of powertrain systems into the overall vehicle architecture, considering the impacts on vehicle performance.	L3
CO6	Assess and optimize the role of powertrain systems in emissions and fuel economy, employing sustainable practices in powertrain design.	L3

COURSE CONTENT:	
MODULE 1	08Hrs

Introduction to Vehicle Dynamics offers an overview of the fundamental principles of vehicle dynamics. It includes topics such as forces and moments, tire dynamics, and vehicle motion (longitudinal, lateral, and vertical).	
MODULE 2	08Hrs
Vehicle Ride and Handling delves deeper into vehicle dynamics with a focus on ride comfort and handling. Students will learn about suspension systems, steering dynamics, and vehicle stability control systems.	
MODULE 3	08Hrs
Basics of Powertrain Systems introduces the basics of powertrain systems. It covers topics such as engine operation, transmission systems, drivetrain components, and the role of powertrain in vehicle performance.	
MODULE 4	07Hrs
Advanced Powertrain Technologies provides insight into the latest advancements in powertrain technologies. This includes hybrid and electric powertrains, fuel cell technologies, and energy storage systems.	
MODULE 5	08Hrs
Powertrain Integration and Vehicle Performance concludes the course with a focus on the integration of powertrain systems into the overall vehicle architecture and its impact on vehicle performance. Topics include powertrain control strategies, emissions, and fuel economy.	

Textbooks:

Gillespie, T.D., "Fundamentals of Vehicle Dynamics", Society of Automotive Engineers Inc., 1992.

Stone, R., "Introduction to Internal Combustion Engines", 4th Edition, Palgrave, 2012.

References:

Wong, J. Y., "Theory of Ground Vehicles", 4th Edition, Wiley, 2008.

Heywood, J. B., "Internal Combustion Engine Fundamentals", McGraw Hill, 1988.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4708					
TITLE OF THE COURSE	ADVANCED ENERGY STORAGE					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To provide comprehensive knowledge about various energy storage systems
- To develop skills in evaluating and designing energy storage systems
- To introduce emerging technologies in energy storage and their practical applications
- To foster understanding of the integration, management, and economic aspects of energy storage systems

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply knowledge of various energy storage systems.	L3
CO2	Evaluate mechanical and thermal energy storage systems.	L4
CO3	Design electrochemical energy storage systems.	L3
CO4	Implement emerging energy storage technologies in practical scenarios.	L4
CO5	Assess integration strategies for energy storage.	L3
CO6	Formulate energy storage management plans.	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Fundamental concepts of energy storage, an overview of different technologies, and an understanding of the role and importance of energy storage in modern power systems.	
MODULE 2	08Hrs
Specific types of mechanical energy storage systems like Pumped Hydro Storage (PHS) and Compressed Air Energy Storage (CAES). The module will also delve into thermal energy storage technologies, highlighting their principles, types, and applications.	
MODULE 3	08Hrs
Batteries and supercapacitors, both fundamental components of electrochemical energy storage, different battery technologies and their performance, lifespan, safety, and environmental considerations.	

MODULE 4	07Hrs
Generation of energy storage technologies, including hydrogen storage, fuel cells, and advanced battery systems. Latest innovations in thermal and kinetic energy storage.	
MODULE 5	08Hrs
Integration of storage technologies into renewable energy systems. Economic and regulatory considerations surrounding energy storage and its role in grid services.	

Textbooks:

- "Energy Storage" by Robert Huggins. Publisher: Springer; 2016 edition.
- "Electrochemical Energy Storage for Renewable Sources and Grid Balancing" by Patrick T. Moseley and Jurgen Garche. Publisher: Elsevier; 2015 edition.

Reference book:

- "Advances in Batteries for Medium and Large-Scale Energy Storage" edited by Chris Menictas, Maria Skyllas-Kazacos, and Tuti Mariana Lim. Publisher: Woodhead Publishing; 2015 edition.
- "The Handbook of Lithium-Ion Battery Pack Design" by John Warner. Publisher: Elsevier; 2015 edition.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4709					
TITLE OF THE COURSE	COMPUTATIONAL FLUID DYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- Introduce Governing Equations of viscous fluid flows

- Introduce numerical modelling and its role in the field of fluid flow and heat transfer
- Enable the students to understand the various discretization methods, solution procedures and turbulence modelling.
- Create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Solve Fluid Dynamics Problems Using Governing Equations.	L3
CO2	Implement Finite Difference and Finite Volume Methods.	L4
CO3	Apply Finite Volume Method for Convection Diffusion.	L3
CO4	Perform Flow Field Analysis.	L4
CO5	Utilize Turbulence Models.	L3
CO6	Generate Mesh for CFD Analyses.	L3

COURSE CONTENT:	
MODULE 1	
08Hrs	
Governing equations and boundary conditions: Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent-Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.	
MODULE 2	
08Hrs	
Finite difference and finite volume methods for diffusion: Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three – dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.	
MODULE 3	
08Hrs	
Finite volume method for convection diffusion: Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.	
MODULE 4	
07Hrs	

Flow field analysis: Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.	
MODULE 5	08Hrs
Turbulence models and mesh generation: Turbulence models, mixing length model, Two equation (k- ϵ) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools	

Text books

- Versteeg, H.K., and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Second Edition Pearson Education Ltd. 2007.
- Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.

Reference books

- Patankar, S.V. "Numerical Heat Transfer and Fluid Flow, Hemisphere" Publishing Corporation, 2004.
- Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, 2002.
- Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005
- Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4710					
TITLE OF THE COURSE	OPERATIONS MANAGEMENT					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To equip students with fundamental knowledge and skills in operations management
- To develop proficiency in process analysis and improvement techniques
- To provide understanding and application skills in supply chain and logistics

management

- To instill competence in capacity and production planning, project management, and operations management in the service sector

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply Principles of Operations Management.	L3
CO2	Utilize Process Analysis and Improvement Techniques.	L4
CO3	Optimize Supply Chain and Logistics Management Strategies.	L3
CO4	Implement Capacity and Production Planning Techniques.	L4
CO5	Execute Effective Project Management.	L3
CO6	Implement Operations Management in Service Sector.	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Introduction to Operations Management : Overview of operations management – Definitions and terminologies – Role of operations in organizational strategy – Operations strategy and competitiveness – Decision making in operations management.	
MODULE 2	08Hrs
Process Analysis and Improvement Concept of process – Process mapping and flowchart – Process performance metrics – Process improvement techniques – Lean principles and Six Sigma – Quality management and statistical process control.	
MODULE 3	08Hrs
Supply Chain and Logistics Management Introduction to supply chain management – Role of logistics in operations – Strategic and operational issues in supply chain management – Inventory management – Techniques for demand forecasting.	
MODULE 4	07Hrs
Capacity and Production Planning Capacity planning strategies – Factors affecting capacity decisions – Production planning methods: MRP, ERP, JIT – Workforce planning and scheduling – Facility location and layout planning.	
MODULE 5	08Hrs

Project and Operations Management in Services Concept of project management – Project planning and control – Critical path method (CPM) and Program Evaluation and Review Technique (PERT) – Operations management in services: characteristics, service delivery process, service quality management.

Textbooks:

"Operations Management" by William J. Stevenson. Publisher: McGraw-Hill/Irwin; 13th edition.

"Operations Management: Processes and Supply Chains" by Lee J. Krajewski, Manoj K. Malhotra, and Larry P. Ritzman. Publisher: Pearson; 12th edition.

Reference Materials:

"Production and Operations Management" by S.N. Chary. Publisher: McGraw-Hill; 6th edition.

"The Goal: A Process of Ongoing Improvement" by Eliyahu M. Goldratt and Jeff Cox. Publisher: North River Press; 30th Anniversary edition.

PROGRAM ELECTIVE – V

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4711					
TITLE OF THE COURSE	Robot Vision Systems					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To introduce students to the fundamentals of robot vision systems and their role in robotics and automation.
- To provide an understanding of the key concepts, techniques, and algorithms used in robot vision systems.
- To enable students to design, implement, and evaluate vision-based solutions for various robotic applications.
- To develop critical thinking and problem-solving skills in the context of robot vision

systems.

- To explore the challenges and future trends in the field of robot vision systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Implement Image Processing Techniques in Robot Vision Systems.	L4
CO2	Develop Object Detection and Recognition Algorithms.	L3
CO3	Apply 3D Vision Techniques in Robotics.	L3
CO4	Design and Implement Navigation and Mapping Systems.	L3
CO5	Develop Vision-Based Grasping and Manipulation Techniques.	L4
CO6	Integrate Human-Robot Interaction into Robot Vision Systems.	L3

COURSE CONTENT:	
Module 1: Introduction to Robot Vision Systems	
08Hrs	
Course Overview, History and Evolution of Robot Vision Systems, Importance and Applications of Robot Vision in Robotics, Components of a Robot Vision System, Sensors and Perception in Robots, Introduction to Image Processing and Analysis	
MODULE 2	
08Hrs	
Image Formation and Image Sensing, Image Preprocessing Techniques (Filtering, Enhancement, etc.), Image Segmentation, Feature Extraction Techniques (Edges, Corners, Descriptors, etc.), Image Representation and Feature Encoding, Hands-on lab sessions using image processing libraries	
MODULE 3	
08Hrs	
Object Detection vs. Object Recognition, Image Feature Matching Template Matching Object Detection using Machine Learning (e.g., Haar cascades, CNNs), Object Recognition using Deep Learning, Practical exercises on object detection and recognition algorithms	
MODULE 4	
07Hrs	
Depth Perception and Stereopsis Structured Light and Time-of-Flight Cameras, 3D Point Cloud Processing, 3D Object Reconstruction and Pose Estimation, Scene Understanding and Semantic Segmentation, Hands-on lab sessions on 3D vision techniques	
MODULE 5	
08Hrs	

Robot Navigation and Mapping using Vision, Grasping and Manipulation with Robot Vision, Vision-based Localization and Simultaneous Localization and Mapping (SLAM), Human-Robot Interaction and Social Robot Vision, Ethical Considerations in Robot Vision Systems, Emerging Trends and Future Directions in Robot Vision	

TEXT BOOKS:

1. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES:

3. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004..
4. Richard D. Klafter, Robotic Engineering, Prentice Hall of India Pvt., Ltd., 2001.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4712					
TITLE OF THE COURSE	ROBOT PROGRAMMING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To introduce students to the fundamental concepts and principles of robot programming.
- To familiarize students with different programming languages and platforms commonly used in robotics.
- To provide hands-on experience in designing, implementing, and debugging robot programs.
- To enable students to develop robot behaviors and control strategies for various robotic

systems.

- To foster problem-solving skills and algorithmic thinking in the context of robot programming.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Select appropriate programming languages and platforms for specific robotic applications.	L2
CO2	Design and implement robot behaviors and control strategies using various techniques.	L2
CO3	Apply behavior-based and reactive approaches to control robots in dynamic environments.	L3
CO4	Create and execute a complete robot programming project, including simulation and testing.	L3
CO5	Analyze and optimize robot programs for improved performance.	L3

COURSE CONTENT:	
Module 1: Introduction to Robot Programming	08Hrs
Course Overview, Importance and Role of Robot Programming in Robotics, Types of Robots and Robot Programming Paradigms, Robot Programming Languages (e.g., C/C++, Python, ROS), Robot Operating Systems (ROS) Basics, Hands-on: Setting up the programming environment	
Module 2: Robot Perception and Sensing	08Hrs
Understanding Robot Sensors and Actuators, Interfacing with Robot Hardware, Processing Sensor Data for Perception, Introduction to Robot Vision and Image Processing, Sensor Fusion and Multi-sensor Integration Practical exercises on working with robot sensors	
Module 3: Robot Motion Planning and Control	08Hrs
Kinematics and Dynamics of Robotic Systems Robot Motion Planning Techniques (e.g., Path Planning, Trajectory Generation) Obstacle Avoidance and Collision Detection, PID Control and Feedback Loops, Introduction to Inverse Kinematics and Control, Hands-on: Implementing basic robot motions and control algorithms	
Module 4: Behavior-based and Reactive Robotics	07Hrs
Behavior-based Paradigm in Robotics, Finite State Machines for Robot Behavior Control, Reactive Systems and Behavior Arbitration, Multi-Robot Systems and Coordination, Introduction to Reinforcement Learning in Robotics, Practical exercises on behavior-based robot programming	
Module 5: Robot Applications and Project Development	08Hrs

Robot Programming for Specific Applications (e.g., Mobile Robotics, Manipulators), Project Planning and Designing Robot Behaviors, Robot Simulation and Testing, Project Implementation, Debugging, and Optimization Project Presentations and Demonstrations, Future Trends and Advanced Topics in Robot Programming	

TEXT BOOKS:

1. "Programming Robots with ROS: A Practical Introduction to the Robot Operating System" by Morgan Quigley, Brian Gerkey, William D. Smart.
2. Robotics, Vision and Control: Fundamental Algorithms in MATLAB" by Peter Corke.

REFERENCES:

1. Modern Robotics: Mechanics, Planning, and Control" by Kevin M. Lynch, Frank C. Park - An in-depth treatment of robot mechanics, planning algorithms, and control theory.
2. Robot Dynamics and Control" by Mark W. Spong, Seth Hutchinson, M. Vidyasagar

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4713					
TITLE OF THE COURSE	Intelligent Manufacturing Systems					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To introduce students to the principles, concepts, and technologies underlying intelligent manufacturing systems.
- To develop an understanding of how advanced technologies such as AI, IoT, and robotics can be integrated to optimize manufacturing processes.
- To familiarize students with the challenges and opportunities in implementing intelligent manufacturing systems in real-world industrial settings.

- To enable students to critically analyze and evaluate the impact of intelligent manufacturing on productivity, quality, and sustainability.
- To equip students with the knowledge and skills necessary to design, develop, and deploy intelligent manufacturing solutions.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Analyze real-world manufacturing scenarios and identify opportunities for intelligent system integration.	L2
C02	Design and implement intelligent manufacturing solutions using AI, IoT, and robotics technologies.	L2
C03	Evaluate the impact of intelligent manufacturing on productivity, quality, and sustainability in industrial contexts.	L3
C04	Collaborate effectively in teams to solve complex manufacturing problems using intelligent technologies.	L3
C05	Analyze and optimize robot programs for improved performance.	L3

COURSE CONTENT:	
Module 1: Introduction to Intelligent Manufacturing Systems	08Hrs
Overview of intelligent manufacturing systems and their role in Industry 4.0. Historical development and evolution of manufacturing technologies. Key components and technologies in intelligent manufacturing (AI, IoT, Cyber-Physical Systems, etc.). Applications and benefits of intelligent manufacturing in different industries.	
Module 2: Smart Sensors and Data Acquisition	08Hrs
Understanding the role of sensors and data acquisition in intelligent manufacturing. Types of sensors used in manufacturing processes and their working principles. Data processing, fusion, and interpretation for decision-making. Real-time monitoring and control of manufacturing processes using sensor data.	
Module 3: Artificial Intelligence in Manufacturing	08Hrs
Introduction to Artificial Intelligence (AI) and its relevance in manufacturing. Machine learning algorithms for predictive maintenance, quality control, and optimization. Robotics and automation in intelligent manufacturing systems. Case studies of AI-driven manufacturing applications.	
Module 4: Internet of Things (IoT) in Manufacturing	07Hrs
Fundamentals of the Internet of Things and its integration with manufacturing systems. Industrial IoT protocols and communication standards. IoT-enabled	

supply chain management and inventory control. Security and privacy considerations in IoT-enabled manufacturing.	
Module 5: Implementing and Managing Intelligent Manufacturing Systems	
Design considerations for intelligent manufacturing systems. Integration of intelligent manufacturing technologies with legacy systems. Challenges, risks, and mitigations in adopting intelligent manufacturing. Lifecycle management and continuous improvement of intelligent manufacturing systems.	08Hrs

TEXT BOOKS:

1. "Intelligent Manufacturing Systems", Andrew Kusiak, Edition: 2nd, Publisher: Prentice Hall Publication, 2001.
2. "Intelligent Manufacturing: Multi-Agent Systems and Virtual Environments", Lihui Wang, Andrew Kusiak, Edition: 4th, Springer, 2009

REFERENCES:

1. "Intelligent Manufacturing: Reviving U.S. Manufacturing Including Lessons Learned from Delphi Packard Electric and General Motors", Jay Lee, Helu Miao, Edition: 1st, LAP Lambert Academic Publishing, 2010

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4714					
TITLE OF THE COURSE	Powder Metallurgy Manufacturing					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- Understand the principles and fundamentals of powder metallurgy as a manufacturing process.
- Identify the different powder metallurgy techniques and their applications in various industries.
- Gain knowledge of the properties and characteristics of powder materials used in

manufacturing processes.

- Analyze the advantages and limitations of powder metallurgy compared to conventional manufacturing methods.
- Develop the skills necessary to design, produce, and assess powder metallurgy components.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply powder metallurgy principles to develop manufacturing solutions for specific industrial applications.	L2
CO2	Design and optimize powder metallurgy processes for enhanced component performance.	L2
CO3	Evaluate the properties and characteristics of powder materials to select appropriate materials for manufacturing.	L3
CO4	Assess the advantages and limitations of powder metallurgy in comparison to traditional manufacturing methods.	L3
CO5	Demonstrate proficiency in fabricating powder metallurgy components and conducting quality control tests.	L3

COURSE CONTENT:	
Module 1: Introduction to Powder Metallurgy	08Hrs
Overview of powder metallurgy and its historical development. Fundamentals of powder metallurgy processes. Powder characteristics and properties. Powder production methods.	
Module 2: Powder Compaction and Shaping	08Hrs
Principles of powder compaction. Types of compaction presses and their operation. Tooling design for powder compaction. Post-compaction shaping techniques.	
Module 3: Sintering and Heat Treatment	08Hrs
Fundamentals of sintering and its mechanisms. Sintering furnaces and atmosphere control. Sintering kinetics and densification. Heat treatment of powder metallurgy components.	
Module 4: Secondary Operations in Powder Metallurgy	07Hrs
Debinding techniques for removing binders from green compacts. Post-sintering treatments (e.g., impregnation, infiltration, etc.). Finishing operations for powder metallurgy components.	
Module 5: Powder Metallurgy Applications and Advanced Techniques	08 Hrs
Automotive applications of powder metallurgy components. Aerospace and defense industry applications. Powder metallurgy in biomedical and consumer goods. Metal injection molding (MIM) and its advantages. Powder forging and its application in producing high-strength components. Powder spraying and	

coating techniques.	

TEXT BOOKS:

1. Powder Metallurgy Science, Randall M. German, Edition: 4th, Metal Powder Industries Federation (MPIF), 2017
2. Powder Metallurgy: Principles and Applications", Brian Cantor, F. C. Campbell, Patrick Grant, Edition: 1st, Cambridge University Press, 2014

REFERENCES:

3. Advances in Powder Metallurgy: Properties, Processing, and Applications", Editor: Isaac Chang, Yuyuan Zhao, Mingzhi Chen, Woodhead Publishing, 2013

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4715					
Course Name	Powertrain Integration in Hybrid Electric Vehicles (HEV)					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To provide students with a comprehensive understanding of the powertrain integration in Hybrid Electric Vehicles (HEVs).
- Explain different classifications of HEVs and the principles of energy management strategies.

- Familiarize students with the key components of HEV powertrains and their functions.
- To equip students with the knowledge and skills necessary to design, analyze, and optimize powertrain systems in HEVs, considering factors such as energy efficiency, performance, and environmental impact.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the fundamentals of hybrid electric vehicle powertrains and their key components.	L2
CO2	Analyze the interactions between different powertrain components in HEVs.	L2
CO3	Design and optimize powertrain systems to achieve desired performance and efficiency in HEVs.	L3
CO4	Evaluate the environmental impact and benefits of integrating specific powertrain technologies in HEVs.	L3
CO5	Apply theoretical knowledge to practical scenarios and problem-solving related to powertrain integration in HEVs.	L3

COURSE CONTENT:	
Module 1: Introduction to Hybrid Electric Vehicles	
Introduction to HEVs and their advantages, Classification of HEVs: Series, Parallel, Series-Parallel, Energy management strategies in HEVs, Regenerative braking and energy recovery	08Hrs
Module 2: Powertrain Components in HEVs	08Hrs
Internal combustion engines (ICEs) in HEVs Electric motors and generators High voltage batteries and energy storage systems Power electronics and inverters	
Module 3: Powertrain Integration and Control	08Hrs
Powertrain control strategies and architectures, Powertrain modeling and simulation techniques, Energy flow analysis in HEVs, Control algorithms for optimal power distribution	
Module 4: Powertrain Efficiency and Optimization	07Hrs
Efficiency analysis of powertrain components, Powertrain optimization for performance and fuel economy, Advanced powertrain technologies: Plug-in Hybrid Systems (PHEVs), Range Extenders, etc. Design considerations for powertrain integration	
Module 5: Environmental Impact and Future Trends	08Hrs
Environmental impact assessment of HEVs, Life cycle analysis and carbon footprint, Emerging trends and future developments in powertrain integration Sustainable transportation and the role of HEVs in the future	

TEXT BOOKS:

1. Hybrid Electric Vehicle Design and Control: Intelligent Omnidirectional Hybrids" by Simona Onori, Lorenzo Serrao, and Giorgio Rizzoni
2. Advanced Electric Drive Vehicles" by Ali Emadi
3. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design" by Mehrdad Ehsani, Yimin Gao, and Ali Emadi

REFERENCES:

1. Hybrid Electric Vehicle Technology" by H. Johannes Helmut and Qiyan Wu
2. Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4716					
Course Name	ENERGY MANAGEMENT AND CONTROL STRATEGIES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To provide students with a solid understanding of energy management principles and their importance in sustainable development.
- To familiarize students with various energy control strategies and technologies used to

- enhance energy efficiency and conservation.
- To develop students' abilities to analyze energy consumption patterns, identify areas of improvement, and recommend energy-saving measures.
- To enable students to assess the economic and environmental implications of different energy management strategies.
- To prepare students to design and implement energy management plans that meet the specific needs and requirements of different industries.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Evaluate energy consumption patterns and identify opportunities for energy conservation in industrial and commercial facilities.	L2
CO2	Implement and apply advanced energy control strategies, such as demand response, load shedding, and peak shaving, to optimize energy consumption.	L2
CO3	Analyze the economic feasibility of energy management projects, considering factors such as payback period, return on investment, and cost-benefit analysis.	L3
CO4	Formulate comprehensive energy management plans tailored to the unique requirements and constraints of different organizations.	L3
CO5	Demonstrate a thorough understanding of environmental implications related to energy usage and propose strategies to reduce carbon footprint and greenhouse gas emissions.	L3

COURSE CONTENT:	
Module 1: Introduction to Energy Management	
Energy management fundamentals, Global energy scenario and sustainability Energy auditing and performance assessment, Energy efficiency standards and regulations	08Hrs
Module 2: Energy Control Strategies and Technologies	
Load management and peak demand reduction, Building automation systems and smart controls, Energy storage systems and integration, Renewable energy integration and microgrids	08Hrs
Module 3: Economic and Financial Aspects of Energy Management	
Cost-benefit analysis and life-cycle costing, Energy pricing and tariff structures Financing energy management projects, Incentives and subsidies for energy conservation	08Hrs
Module 4: Environmental Impact and Green Initiatives	
Environmental aspects of energy consumption, Carbon footprint assessment and reduction strategies, Energy-efficient building design and LEED certification, Corporate social responsibility and sustainable practices	07Hrs

Module 5: Energy Management Plan Development and Implementation	08Hrs
Energy data analytics and management software, Developing customized energy management plans, Stakeholder engagement and change management Monitoring, evaluation, and continuous improvement	

TEXT BOOKS:

1. Energy Management Principles: Applications, Benefits, Savings" by Craig B. Smith and Kelly E. Parmenter
2. Energy Management Handbook" by Wayne C. Turner and Steve Doty
3. Industrial Energy Management: Principles and Applications" by Alaa El-Sayed Abdel-Aal

REFERENCES:

1. Energy Efficiency: Principles and Practices" by Ibrahim Dincer and Marc A. Rosen
2. Handbook of Energy Audits" by Albert Thumann and William J. Younger
3. Energy Economics: Concepts, Issues, Markets, and Governance" by Subhes C. Bhattacharyya

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4717					
TITLE OF THE COURSE	AUTOMOBILE ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To understand basics of Automobile Engineering & various automotive system.
- To understand vehicle layout, vehicle specifications & important of automobile.
- To make the student conversant with drive train & transmission.
- Understand the various Automobile Electrical System, Vehicle performance & theirsafety

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyze Development and Role of Automobile Engineering.	L3
CO2	Evaluate Clutches, Gearboxes, and Drive Systems.	L3
CO3	Design Axles, Steering, Suspension, and Brake Systems.	L3
CO4	Analyze Vehicle Performance and Safety Parameters.	L3
CO5	Implement Understanding of Vehicle Battery and Accessory Systems.	L4
CO6	Perform Vehicle Maintenance and Servicing.	L3

MODULE 1	08Hrs
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	
MODULE 2	08Hrs
Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission, Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive.	
MODULE 3	08Hrs
Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. Suspension: Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), damping and shock absorbers Brakes: Types of brake systems - drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.	
MODULE 4	07Hrs

Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise.	
MODULE 5	08Hrs
Batteries: Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods. Lighting System & Accessories: Insulated & earth return systems, positive & negative earth systems, electrical fuel pump, speedometer, fuel, oil & temperature gauges, horn, wiper system, trafficator, sensors and actuators, electronic control unit, traction control devices. Vehicle maintenance Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system.	

TEXT BOOKS :

1. William H. Crouse, "Automotive Mechanics", Tata McGraw Hill Publishing House.

REFERENCES :

3. K. Newton and W. Seeds, T.K. Garrett, "Motor Vehicle", 13th Edition, Elsevier publications
4. Hans Hermann Braess, Ulrich Seiffen, "Handbook of Automotive Engineering", SAE Publications

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4718					
Course Name	TRIBOLOGY AND BEARING DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To introduce students to the fundamentals of tribology, including the study of friction, wear, and lubrication mechanisms.

- To provide an in-depth understanding of bearing types, their principles of operation, and their applications in mechanical systems.
- To familiarize students with the design considerations and selection criteria for bearings in different engineering scenarios.
- To enable students to analyze and evaluate tribological performance, predict wear rates, and optimize bearing design.
- To prepare students to apply their knowledge to solve real-world tribology and bearing challenges in engineering practice.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the principles of tribology and the significance of friction, wear, and lubrication in mechanical systems.	L2
CO2	Describe the different types of bearings, their construction, and their applications in various engineering fields.	L2
CO3	Analyze and evaluate the performance of bearings under different loading conditions and operating environments.	L3
CO4	Design and select appropriate bearings for specific engineering applications based on performance requirements and constraints.	L3
CO5	Apply tribological concepts and knowledge to address practical problems related to friction, wear, and bearing design.	L3

COURSE CONTENT:	
Module 1: Introduction to Tribology	
Definition and scope of tribology, Friction and its classification, Wear mechanisms and types, Lubrication regimes and lubricants	08Hrs
Module 2: Principles of Bearing Design	
Types of bearings: rolling, sliding, and fluid film bearings, Bearing materials and properties, Load capacity and bearing life calculations, Bearing standards and specifications	08Hrs
Module 3: Bearing Applications and Selection	
Bearing arrangements in mechanical systems, Bearing failure analysis and troubleshooting, Specialty bearings and advanced applications, Bearing selection based on load, speed, and environment	08Hrs
Module 4: Lubrication in Bearings	
Lubrication theory and principles, Lubricant types and properties, Lubrication systems and methods, Lubricant testing and condition monitoring	07Hrs
Module 5: Advanced Topics in Tribology and Bearing Design	
	08Hrs

Surface engineering and coatings for enhanced tribological performance, Bearing dynamics and vibration analysis, Green tribology and sustainable bearing design, Case studies and industry best practices	

TEXT BOOKS:

1. Tribology and Bearing Design" by Michael M. Khonsari and E. Richard Booser
2. "Principles and Applications of Tribology" by Bharat Bhushan
3. "Bearing Design in Machinery: Engineering Tribology and Lubrication" by Avraham Harnoy

REFERENCES:

1. Tribology: Friction and Wear of Engineering Materials" by Ian Hutchings
2. "Lubrication Fundamentals" by Don M. Pirro and Robert W. Bruce
3. "Bearing Design and Fitting" by A. J. Esdaile and H. A. Rothberg

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4802					
Course Name	ADVANCED AI FOR ROBOTICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To inculcate deep understanding of advanced AI techniques in the context of robotics.

- To enable students to implement and design AI models for specific robotic applications.
- To provide hands-on experience with current AI tools and frameworks relevant to robotics.
- To foster critical thinking and analysis of AI applications in robotics, considering strengths, weaknesses, and societal implications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply Machine Learning Techniques to Robotic Systems.	L3
CO2	Utilize Computer Vision in Robotics.	L2
CO3	Implement AI-Based Decision Making and Control.	L4
CO4	Analyze and Evaluate AI Techniques in Robotics.	L3
CO5	Design AI Models for Specific Robotic Applications.	L3
CO6	Apply Advanced AI Concepts in Robotics.	L3

COURSE CONTENT:	
Module 1	
Introduction to Advanced AI for Robotics Topics include: Review of basic AI concepts, Introduction to AI for robotics, Role and application of AI in Robotics, Brief overview of robotic systems, Different types of robots and their AI requirements.	08Hrs
Module 2	
Machine Learning for Robotics Topics include: Supervised, Unsupervised, and Reinforcement learning in robotics context, Deep learning techniques for perception, Prediction modeling for robotic control, Robot learning from demonstration, Hands-on lab sessions with Machine Learning frameworks.	
Module 3	
Perception and Vision for Robotics Topics include: Computer Vision techniques for robotics, Object detection and recognition, Semantic segmentation and scene understanding, Depth perception and 3D vision, Multimodal sensor fusion for enhanced perception.	08Hrs

Module 4	07Hrs
AI-based Decision Making and Control Topics include: Path planning and navigation, Decision making under uncertainty, Reinforcement learning for control policy generation, Multi-robot systems and collaborative AI, Evolutionary algorithms for optimization in robotics.	
Module 5	08Hrs
Advanced Topics and Future Directions Topics include: Ethics and societal implications of AI in robotics, Case studies of AI applications in modern robotic systems, Emerging trends in AI for robotics - Explainable AI, AI for Human-Robot Interaction, Challenges and opportunities in the field.	

Textbooks:

- "Probabilistic Robotics" by Sebastian Thrun, Wolfram Burgard, and Dieter Fox, MIT Press, 2005.
- "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig, Pearson, 3rd Edition, 2009.

References:

- "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016.
- "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto, MIT Press, 2nd Edition, 2018.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4803					
Course Name	ROBOT SIMULATION & OFFLINE PROGRAMMING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To introduce students to the principles and techniques of robot simulation and offline

programming.

- To provide hands-on experience with software tools used in robot simulation and offline programming.
- To enable students to develop, test, and implement offline robot programs.
- To explore the integration of AI and machine learning in robot simulation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Implement Fundamentals of Robot Simulation.	L4
CO2	Apply Principles of Offline Robot Programming.	L3
CO3	Analyze Practical Applications of Robot Simulation.	L3
CO4	Develop Offline Robot Programs.	L3
CO5	Utilize Software Tools for Simulation and Offline Programming.	L3
CO6	Incorporate AI and Machine Learning in Robot Simulation.	L3

COURSE CONTENT:	
Module 1	
Introduction to Robot Simulation and Offline Programming Topics: Overview of robot simulation, Introduction to offline programming, Benefits and challenges of simulation and offline programming, General robotics and programming review.	08Hrs
Module 2	
Fundamentals of Robot Simulation Topics: Essential elements of robot simulation, Working with robot models, Interpreting robot kinematics and dynamics, Creating virtual environments, Simulation of robot sensors and perception systems.	08Hrs
Module 3	
Principles of Offline Robot Programming Topics: Overview of robot programming languages, Developing offline robot programs, Testing and debugging of robot programs, Integrating robot programs into simulated environments, Safe robot operation through offline programming.	08Hrs
Module 4	
	07Hrs

Practical Applications of Robot Simulation and Offline Programming Topics: Case studies in manufacturing, healthcare, autonomous robots, and other sectors, Performance analysis and optimization using simulation, Human-robot interaction simulation, Collision detection and avoidance in simulation, Real-world implementation of offline programs.	
Module 5	08Hrs
Advanced Topics and Software Tools in Robot Simulation and Offline Programming Topics: Emerging trends in simulation and offline programming, Overview of software tools for robot simulation (such as ROS, Gazebo, V-REP, RoboDK), Offline programming software (such as RobotStudio, Roboguide), Integration of AI and Machine Learning in robot simulation, Future directions in simulation and offline programming.	

Textbooks:

- "Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Wiley, 1st Edition, 2005.
- "Introduction to Robotics: Analysis, Control, Applications" by Saeed B. Niku, Wiley, 2nd Edition, 2010.

References:

- "Robotics, Vision and Control: Fundamental Algorithms in MATLAB" by Peter Corke, Springer, 2nd Edition, 2017.
- "Robot Programming: A Guide to Controlling Autonomous Robots" by Cameron Hughes and Tracey Hughes, Que Publishing, 1st Edition, 2016.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4804					
Course Name	ADDITIVE MANUFACTURING FOR MEDICAL APPLICATIONS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To understand the basic principles and technologies in additive manufacturing for

medical applications.

- To familiarize with the various biocompatible materials used in medical additive manufacturing.
- To learn the different AM techniques and their application in the medical field.
- To develop the ability to design and optimize CAD models for medical additive manufacturing.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply Principles of Additive Manufacturing.	L3
CO2	Select Biocompatible Materials.	L3
CO3	Implement AM Techniques in Medical Applications.	L4
CO4	Design Models for Medical AM.	L3
CO5	Follow Regulatory Guidelines.	L3
CO6	Analyze Applications of Medical AM.	L3

COURSE CONTENT:	
Module 1	
Introduction to Additive Manufacturing and Medical Applications Topics: Overview of additive manufacturing (AM), History and evolution of AM in medical field, AM technologies used in medical applications, Benefits and challenges of using AM in medical industry.	08Hrs
Module 2	
Biocompatible Materials for Additive Manufacturing Topics: Understanding biocompatible materials, Materials used in AM for medical applications (polymers, metals, ceramics, and biocomposites), Properties and selection of biocompatible materials, Case studies of material use in medical AM.	08Hrs
Module 3	
Additive Manufacturing Techniques in Medical Applications Topics: Overview of AM techniques used in medical applications such as Stereolithography (SLA), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), Direct Metal Laser Sintering (DMLS), and Bioprinting, Case	08Hrs

studies on the use of these techniques in creating medical devices, implants, and more.	
Module 4	07Hrs
Design and Modeling for Medical Additive Manufacturing Topics: Introduction to design principles for AM, Design considerations for medical applications, Computer-Aided Design (CAD) for AM, Generating and optimizing models for medical AM, Regulatory considerations in the design of AM medical devices.	
Module 5	08Hrs
Applications and Future Directions of Medical Additive Manufacturing Topics: Detailed examination of AM applications in medical field including custom implants, prosthetics, tissue engineering, and pharmaceuticals, Challenges and solutions in medical AM, Ethical considerations, Emerging trends and future directions in AM for medical applications.	

Textbooks:

- "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing" by Ian Gibson, David Rosen, Brent Stucker, Springer, 2nd Edition, 2014.
- "3D Printing in Medicine" by Frank J. Rybicki, Gerald T. Grant, Springer, 1st Edition, 2017.

References:

- "3D Printing of Medical Devices and Tissue Engineering Structures" by Murat Guvendiren, Springer, 1st Edition, 2020.
- "3D Printing Applications in Cardiovascular Medicine" by James K Min, Subhi J Al'Aref, Reza Ardehali, Dudley S Childress, Academic Press, 1st Edition, 2018.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4805					
Course Name	SUSTAINABLE MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To understand the concept of sustainable manufacturing and its importance.
- To learn how to conduct a life cycle assessment (LCA) for manufacturing processes and products.
- To gain knowledge on how to implement energy efficiency measures in manufacturing.
- To develop skills for managing and reducing waste in the manufacturing process.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Assess Impact of Manufacturing Practices.	L3
CO2	Apply Life Cycle Assessment.	L3
CO3	Implement Energy Efficiency Measures.	L4
CO4	Manage and Reduce Waste.	L3
CO5	Incorporate Sustainable Practices in Supply Chain.	L3
CO6	Evaluate Sustainable Manufacturing Systems.	L3

COURSE CONTENT:	
Module 1	
Introduction to Sustainable Manufacturing Topics: Definition and principles of sustainable manufacturing, Role and importance of sustainable manufacturing, Challenges and benefits, Overview of the sustainable manufacturing process, Impact of manufacturing on the environment.	08Hrs
Module 2	
Life Cycle Assessment in Manufacturing Topics: Basics of life cycle assessment (LCA), Phases of LCA - Goal and Scope Definition, Inventory Analysis, Impact Assessment, Interpretation, Case studies of LCA application in manufacturing.	08Hrs
Module 3	
Energy Efficiency in Manufacturing Topics: Importance of energy efficiency in manufacturing, Energy management, Energy audit, Techniques to improve energy efficiency, Case studies on energy efficient manufacturing systems.	08Hrs

Module 4	07Hrs
Waste Management and Reduction in Manufacturing Topics: Manufacturing waste types, Impact of waste on environment, Techniques for waste reduction and management, Recycling and reuse in manufacturing, Case studies on waste management in manufacturing industries.	
Module 5	08Hrs
Sustainable Supply Chain and Green Manufacturing Topics: Introduction to sustainable supply chain, Green manufacturing practices, Role of lean and green manufacturing in sustainability, Case studies on implementation of sustainable supply chain and green manufacturing, Future trends in sustainable manufacturing.	

Textbooks:

- "Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives" by Rainer Stark, Günther Seliger, Jérémy Bonvoisin, Springer, 1st Edition, 2017.
- "Green and Lean Management" by Cinzia Battistella, Fabio Nonino, Springer, 1st Edition, 2016.

References:

- "Industrial Ecology and Sustainable Engineering" by T. E. Graedel, B. R. Allenby, Prentice Hall, 1st Edition, 2010.
- "Green Manufacturing: Fundamentals and Applications" by David A. Dornfeld, Springer, 1st Edition, 2013.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4806					
Course Name	ADVANCED PROPULSION SYSTEMS FOR HYBRID ELECTRIC DRIVE VEHICLES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To familiarize students with the concepts and technologies associated with Hybrid Electric Drive Vehicles (HEDVs).
- To develop proficiency in working with electric propulsion systems used in HEDVs.
- To understand how to integrate Internal Combustion Engine (ICE) propulsion systems within hybrid vehicle frameworks.
- To gain practical knowledge of implementing various energy storage systems and managing their usage in HEDVs.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply Knowledge of HEDVs.	L3
CO2	Use Electric Propulsion Systems.	L3
CO3	Integrate ICE in Hybrid Systems.	L3
CO4	Implement Energy Storage Systems.	L4
CO5	Employ Hybrid Energy Management Techniques.	L3
CO6	Evaluate HEDV Performance.	L3

COURSE CONTENT:	
Module 1	
Introduction to Hybrid Electric Drive Vehicles Topics: Overview of Hybrid Electric Drive Vehicles (HEDVs), Types of HEDVs - Mild Hybrid, Full Hybrid, Plug-In Hybrid, History and evolution of HEDVs, Benefits and challenges of HEDVs, Introduction to propulsion systems.	08Hrs
Module 2	
Electric Propulsion Systems Topics: Overview of electric propulsion, Electric machines - Permanent Magnet Synchronous Machines (PMSMs), Induction Machines (IMs), Switched Reluctance Machines (SRMs), Electric propulsion drive configurations, Motor control techniques.	08Hrs
Module 3	
	08Hrs

Internal Combustion Engine (ICE) Propulsion Systems Topics: Principles of operation of ICE, Types of ICE - petrol, diesel, Gasoline Direct Injection (GDI), Engine control unit (ECU), ICE for hybrid applications, Downsizing and supercharging.	
Module 4	07Hrs
Energy Storage Systems Topics: Overview of energy storage technologies, Batteries - Lithium-ion, Nickel-Metal Hydride (NiMH), Lead-acid, Ultracapacitors, Fuel cells, Battery management systems.	
Module 5	08Hrs
Hybrid Energy Management and Control Topics: Hybrid energy management principles, Control strategies - Rule-based control, Optimized control, Predictive control, Evaluation of energy management strategies, Hybrid vehicle simulation and modeling.	

Textbooks:

- "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design" by Mehrdad Ehsani, Yimin Gao, Stefano Longo, CRC Press, 2nd Edition, 2018.
- "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives" by Chris Mi, M. Abul Masrur, David Wenzhong Gao, Wiley, 2nd Edition, 2017.

References:

- "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain, CRC Press, 2nd Edition, 2011.
- "Electric Vehicle Technology Explained" by James Larminie, John Lowry, Wiley, 2nd Edition, 2012.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4807					
Course Name	AUTOMOTIVE ELECTRONICS FOR EV'S					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To understand the fundamentals of Automotive Electronics in the context of Electric Vehicles.
- To study the principles and applications of power electronics in EVs.
- To explore the design and functioning of Battery Management Systems, Control Systems, and Telematics in EVs.
- To evaluate the performance of EVs and keep updated with recent technological advancements in the field.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Design EV Architecture.	L3
CO2	Apply Power Electronics in EV context.	L3
CO3	Implement Battery Management Systems.	L4
CO4	Employ Control Systems in EVs.	L3
CO5	Develop Telematics and Infotainment Systems.	L3
CO6	Evaluate EV Performance.	L3

COURSE CONTENT:	
Module 1	
Introduction to Electric Vehicles (EVs) and Automotive Electronics Topics: History and evolution of EVs, Overview of Automotive Electronics, Role of electronics in EVs, Different types of EVs - BEVs, HEVs, PHEVs, FCEVs.	08Hrs
Module 2	
EV Architecture and Power Electronics Topics: Overview of EV architecture, Powertrain components, Role of power electronics in EVs, Power electronic converters (DC-DC, DC-AC, AC-DC), Motor drives.	08Hrs
Module 3	
	08Hrs

Battery Management Systems (BMS) Topics: Role of BMS in EVs, Battery technology for EVs, State of Charge (SoC) and State of Health (SoH) estimation methods, Battery safety and thermal management, Charging and discharging strategies.	
Module 4	07Hrs
EV Control Systems Topics: Introduction to control systems in EVs, Traction control, Braking control, Energy management control strategies, Stability control, Autonomous driving features in EVs.	
Module 5	08Hrs
Telematics and Infotainment Systems Topics: Overview of telematics and infotainment systems, Communication protocols used in EVs, Vehicle to Grid (V2G), Vehicle to Vehicle (V2V), and Vehicle to Infrastructure (V2I) communication, Over-the-air updates, Cybersecurity for EVs.	

Textbooks:

- "Electric Vehicle Technology Explained" by James Larminie and John Lowry, Wiley, 2nd Edition.
- "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design" by Mehrdad Ehsani, Yimin Gao, and Ali Emadi, CRC Press, 2nd Edition.

References:

- "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain, CRC Press, 2nd Edition.
- "Vehicle Power Management: Modeling, Control and Optimization" by Xu Li, Springer, 1st Edition.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4808					
Course Name	FEM- STRUCTURAL MECHANICS APPLICATIONS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- Understand the fundamentals and principles of Finite Element Method in the context of structural mechanics.
- Apply Finite Element Method for solving various structural mechanics problems.
- Develop the ability to model and analyze different types of structural elements and systems.
- Explore advanced applications of Finite Element Method in structural mechanics, including non-linear analysis and fracture mechanics.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Implement FEM in 1D Problems.	L3
CO2	Apply FEM to 2D Problems.	L3
CO3	Solve 3D Structural Problems.	L4
CO4	Analyze Plate and Shell Structures.	L3
CO5	Perform Non-linear Analysis.	L4
CO6	Conduct Fracture and Fatigue Analysis.	L3

COURSE CONTENT:	
Module 1	
Introduction to Finite Element Method (FEM) Topics: History and evolution of FEM, Review of structural mechanics, Overview of FEM in structural mechanics, Discretization, interpolation functions and shape functions, Principle of minimum potential energy.	08Hrs
Module 2	
One-dimensional Problems Topics: Introduction to 1D problems, FEM formulation for axial load deformation problems, FEM formulation for thermal problems, Implementation and solution of 1D problems, Effect of boundary conditions and loadings, Comparison with analytical solutions.	

Module 3	08Hrs
Two-dimensional Problems Topics: Introduction to 2D problems, FEM formulation for plane stress, plane strain and axisymmetric problems, Triangular and quadrilateral elements, Meshing strategies, Implementation and solution of 2D problems, Dealing with complex geometries.	
Module 4	07Hrs
Three-dimensional Problems Topics: Introduction to 3D problems, FEM formulation for 3D elasticity problems, Tetrahedral and hexahedral elements, Meshing strategies, Implementation and solution of 3D problems, Dealing with large deformations and non-linearity.	
Module 5	08Hrs
Advanced Topics in FEM for Structural Mechanics Topics: FEM for plate and shell problems, Introduction to buckling and post-buckling analysis using FEM, Non-linear analysis in FEM, FEM for fracture mechanics and fatigue problems, Introduction to software tools for FEM analysis.	

Textbooks:

- "A First Course in the Finite Element Method", Daryl L. Logan, Cengage Learning; 6th edition.
- "The Finite Element Method: Linear Static and Dynamic Finite Element Analysis", Thomas J.R. Hughes, Dover Publications; 1st edition.

References:

- "Finite Element Procedures", Klaus-Jurgen Bathe, Prentice Hall; 2nd edition.
- "The Finite Element Method in Engineering", Singiresu S. Rao, Butterworth-Heinemann; 6th edition.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4809					
Course Name	ORGANIZATIONAL BEHAVIOUR AND PROFESSIONAL COMMUNICATION					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To provide a comprehensive understanding of Organizational Behaviour.
- To enhance leadership and decision-making skills.
- To improve professional communication skills for business environments.
- To foster ethical sensitivity and corporate social responsibility.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply concepts of organizational behaviour to real-life business situations.	L3
CO2	Formulate strategies for effective group dynamics and team development.	L3
CO3	Implement appropriate leadership styles and decision-making techniques.	L4
CO4	Demonstrate proficiency in professional communication, both written and oral.	L3
CO5	Apply problem-solving and negotiation skills in a variety of organizational contexts.	L4
CO6	Design and implement CSR strategies in alignment with organizational objectives.	L3

COURSE CONTENT:	
Module 1	
Introduction to Organizational Behaviour The nature and significance of Organizational Behaviour. Understanding the relationship between an individual and an organization. Introduction to individual behavior, personality, perception, and attribution.	08Hrs
Module 2	
Group Behaviour and Team Development Concepts of group dynamics and team development. Analysis of roles, norms, conformity, status, and cohesiveness in a group. Techniques for effective team building. Study of conflict management and negotiation skills.	08Hrs
Module 3	
	08Hrs

Leadership and Decision Making Concepts of leadership and the role of a leader. Understanding different leadership styles. Principles of effective decision making. Techniques for problem-solving and decision-making in an organizational context.	
Module 4	07Hrs
Professional Communication Importance of communication in an organization. Barriers to effective communication and ways to overcome them. Study of written, oral, and non-verbal communication. Importance of listening skills and feedback in communication.	
Module 5	08Hrs
Ethics and Corporate Social Responsibility Concepts of professional ethics and ethical dilemmas in organizations. Study of Corporate Social Responsibility (CSR) and its impact on organizational performance. Understanding the influence of culture and diversity in organizational behavior.	

Textbooks:

- "Organizational Behavior", Stephen P. Robbins, Timothy A. Judge, Pearson; 18th edition.
- "Essentials of Business Communication", Mary Ellen Guffey, Dana Loewy, Cengage Learning; 11th edition.

References:

- "Understanding Organizational Behavior", Udai Pareek, Oxford University Press; 3rd edition.
- "Effective Business Communication", Herta A Murphy, Herbert W Hildebrandt, Jane P. Thomas, McGraw Hill Education; 7th edition.

DAYANANDA SAGAR UNIVERSITY

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SCHOOL OF ENGINEERING



**SCHEME & SYLLABUS
FOR
BACHELOR OF TECHNOLOGY (B.Tech.) – 2020**

MECHANICAL ENGINEERING

**(ME)
(upto 8th Semester)
(WITH EFFECT FROM 2020-21)**

SCHEME - B.TECH – 2020-21 ONWARDS**III SEM - MECHANICAL ENGINEERING**

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/ P	C	SEM	COURSE CODE
1	105	20ME2301	COMPLEX VARIABLES AND NUMERICAL METHODS	CR	03	01	--	--	04	*	***
2	105	20ME2302	ENGINEERING MATERIALS	CR	03	--	02	--	04	*	***
3	105	20ME2303	ENGINEERING MECHANICS	CR	03	--	--	--	03	*	***
4	105	20ME2304	THERMODYNAMICS	CR	03	--	--	--	03	*	***
5	105	20ME2305	COMPUTER AIDED MACHINE DRAWING	CR	02	--	04	---	04	*	***
6	105	20ME2306	MECHANICAL MEASUREMENTS	CR	03	--	02	--	04	*	***
7	105	20ME2307	SPECIAL TOPICS – I	CR	01	--	02	--	02	*	***
					18	01	10	-	24		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits

SCHEME - B.TECH – 2020-21 ONWARDS**IV SEM - MECHANICAL ENGINEERING**

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME2401	APPLIED THERMODYNAMICS	CR	02	01	02	--	04	*	***
2	105	20ME2402	MECHANICS OF MATERIALS	CR	02	01	--	--	03	*	***
3	105	20ME2403	FLUID MECHANICS AND MACHINES	CR	03	--	02	--	04	*	***
4	105	20ME2404	MANUFACTURING PROCESS	CR	03	--	02	--	04	*	***
5	105	20ENC001	ECONOMICS FOR ENGINEERS	CR	02	--	--	--	02	*	***
6	105	20ME2405	SPECIAL TOPICS – II	CR	01	--	02	--	02	*	***
					13	02	08	--	19		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits

SCHEME - B.TECH – 2020-21 ONWARDS

V SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME3501	HEAT TRANSFER	CR	03	--	02	--	04	III	20ME2304
2	105	20ME3502	KINEMATICS & THEORY OF MACHINES	CR	03	01	--	--	04	*	***
3	105	20ME3503	DESIGN OF MACHIN ELEMENTS – I	CR	02	01	02	--	04	IV	20ME2302
4	105	20ME3504	MANUFACTURING TECHNOLOGY	CR	03	--	02	--	04	*	***
5	105	20ME35XX	PROFESSIONAL ELECTIVE – I	CR	03	--	--	--	03	*	***
6	105	20OEXXX	OPEN ELECTIVE – I	CR	03	--	--	--	03	*	***
7	105	20ME3505	SPECIAL TOPICS – III	CR	02	--	--	--	02	*	***
					19	02	06	--	24		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – I			
SL.NO	COURSE CODE	COURSE TITLE	Group
1	20ME3506	INTRODUCTION TO ROBOTICS AND AUTOMATION	ROBOTICS & AUTOMATION
2	20ME3507	FUNDAMENTALS TO MACHINE LEARNING & ARTIFICIAL INTELLIGENCE	
3	20ME3508	ADDITIVE MANUFACTURING TECHNOLOGY	ADDITIVE MANUFACTURING
4	20ME3509	AUTOMATED MANUFACTURING SYSTEMS	
5	20ME3510	INTRODUCTION TO HYBRID & ELECTRIC VEHICLES	HYBRID & ELECTRIC VEHICLES
6	20ME3511	AUTOTRONICS	
7	20ME3512	REFRIGERATION AND AIR CONDITIONING	GENERAL
8	20ME3513	TOOL DESIGN	

SCHEME - B.TECH – 2020-21 ONWARDS

VI

SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME3601	DESIGN OF MACHINE ELEMENTS – II	CR	02	01	02	--	04	IV	20ME2402
2	105	20ME3602	FINITE ELEMENT METHODS	CR	02	01	02	--	04	*	***
3	105	20ME3603	MECHANICAL VIBRATIONS	CR	03	--	02	--	04	*	***
4	105	20ME36XX	PROFESSIONAL ELECTIVE – II	CR	03	--	--	--	03	*	***
5	105	20ME36XX	PROFESSIONAL ELECTIVE – III	CR	03	--	--	--	03	*	***
6	105	20OEXXX	OPEN ELECTIVE – II	CR	03	--	--	--	03	*	***
7	105	20ENC002	LAW FOR ENGINEERS	CR	02	--	-	--	02	*	***
					18	02	06	--	23		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE - II			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME3604	DRIVES & CONTROL SYSTEMS	ROBOTICS & AUTOMATION
2	20ME3605	ELECTRICAL MACHINES AND POWER SYSTEMS	
3	20ME3606	MATERIALS FOR AM	ADDITIVE MANUFACTURING
4	20ME3607	PROCESSING OF PLASTICS & COMPOSITES	
5	20ME3608	AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS	HYBRID & ELECTRIC VEHICLES
6	20ME3609	MODEL-BASED EMBEDDED CONTROL SYSTEM DESIGN	
7	20ME3610	RENEWABLE ENERGY SOURCES	GENERAL
8	20ME3611	PRODUCT DESIGN AND MANUFACTURING	

PROGRAM ELECTIVE - III			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME36112	ROBOT KINEMATICS AND DYNAMICS	ROBOTICS & AUTOMATION
2	20ME36113	INDUSTRIAL AUTOMATION-I	
3	20ME36114	COMPUTATIONAL TOOLS FOR AM	ADDITIVE MANUFACTURING
4	20ME36115	MICRO AND NANO FABRICATION TECHNOLOGIES	
5	20ME36116	HEV / EV SYSTEM DESIGN ARCHITECTURE	HYBRID & ELECTRIC VEHICLES
6	20ME36117	MATERIALS AND MANUFACTURING PROCESSES FOR AUTOMOTIVE SYSTEMS	
7	20ME36118	INTERNAL COMBUSTION ENGINES	GENERAL
8	20ME36119	MEMS (MICRO ELECTRO MECHANICAL SYSTEMS)	

SCHEME - B.TECH – 2020-21 ONWARDS**VII****SEM - MECHANICAL ENGINEERING**

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME4701	CONTROL SYSTEMS ENGINEERING	CR	03	--	02	--	04	*	***
2	105	20ME47XX	PROFESSIONAL ELECTIVE – IV	CR	03	--	--	--	03	*	***
3	105	20ME47XX	PROFESSIONAL ELECTIVE – V	CR	03	--	--	--	03	*	***
4	105	20OEXXX	OPEN ELECTIVE – III	CR	03	--	--	--	03	*	***
5	105	20ME4702	MAJOR PROJECT PHASE – I	CR	--	--	--	04	02	*	***
					12	-	02	04	15		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE - IV			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME4703	INDUSTRIAL AUTOMATION-II	ROBOTICS & AUTOMATION
2	20ME4704	AUTOMATION SYSTEM DESIGN	
3	20ME4705	INDUSTRY 4.0 AND IOT	ADDITIVE MANUFACTURING
4	20ME4706	CAD/CAM FOR AM	
5	20ME4707	VEHICLE DYNAMICS ADVANCED POWERTRAIN	HYBRID & ELECTRIC VEHICLES
6	20ME4708	ADVANCED ENERGY STORAGE	
7	20ME4709	COMPUTATIONAL FLUID DYNAMICS	GENERAL
8	20ME4710	OPERATIONS MANAGEMENT	

PROGRAM ELECTIVE - V			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME4711	ROBOT VISION SYSTEMS	ROBOTICS & AUTOMATION
2	20ME4712	ROBOT PROGRAMMING	
3	20ME4713	INTELLIGENT MANUFACTURING SYSTEMS	ADDITIVE MANUFACTURING
4	20ME4714	POWDER METALLURGY MANUFACTURING	
5	20ME4715	POWERTRAIN INTEGRATION IN HEV	HYBRID & ELECTRIC VEHICLES
6	20ME4716	ENERGY MANAGEMENT AND CONTROL STRATEGIES	
7	20ME4717	AUTOMOBILE ENGINEERING	GENERAL
8	20ME4718	TRIBOLOGY AND BEARING DESIGN	

SCHEME - B.TECH – 2020-21 ONWARDS

VIII

SEM - MECHANICAL ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	105	20ME48XX	PROFESSIONAL ELECTIVE – VI	CR	03	--	--	--	03	*	***
2	105	20ME4801	MAJOR PROJECT PHASE– II	CR	--	--	--	20	10	*	***
					03	-	-	10	13		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – VI			
SL.NO	COURSE CODE	COURSE TITLE	GROUP
1	20ME4802	ADVANCED AI FOR ROBOTICS	ROBOTICS & AUTOMATION
2	20ME4803	ROBOT SIMULATION & OFFLINE PROGRAMMING	
3	20ME4804	ADDITIVE MANUFACTURING FOR MEDICAL APPLICATIONS	ADDITIVE MANUFACTURING
4	20ME4805	SUSTAINABLE MANUFACTURING	
5	20ME4806	ADVANCED PROPULSION SYSTEMS FOR HYBRID ELECTRIC DRIVE VEHICLES	HYBRID & ELECTRIC VEHICLES
6	20ME4807	AUTOMOTIVE ELECTRONICS FOR EV'S	
7	20ME4808	FEM- STRUCTURAL MECHANICS APPLICATIONS	GENERAL
8	20ME4809	ORGANIZATIONAL BEHAVIOUR AND PROFESSIONAL COMMUNICATION	

III SEM - MECHANICAL ENGINEERING

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2301					
TITLE OF THE COURSE	COMPLEX VARIABLES AND NUMERICAL METHODS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	56	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	I	-	
2	II		

COURSE OBJECTIVES:

- Understanding basic concepts of Complex variables and Complex integration
- To illustrate its importance through applications to science and Engineering.
- To provide suitable and effective methods called Numerical Methods, for obtaining approximate representative numerical results of the problems.
- Understanding basic concepts of ODE and PDE to illustrate its power and utility through applications to science and Engineering.
- Understanding basic concepts of Probability and Random variables.
- Apply the concepts of Probability distribution in engineering.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyse Complex variables and complex integration	L2
CO2	Study the discrete and continuous random variables	L1
CO3	Analyse various distributions related to discrete and continuous random variables	L3
CO4	Analyse numerically the solution for ODEs	L3
CO5	Analyse numerically the solution for PDEs	L3
CO6	Apply knowledge or Mathematics in Science and Engineering.	L3

COURSE CONTENT:

MODULE 1	10Hrs
COMPLEX VARIABLES Complex function, Limits, Continuity, differentiability, Analytic Functions, CRequations, and Properties of Analytic functions.	

Self-Learning Component : Complex number and its properties	
MODULE 2	12Hrs
INTEGRATION IN THE COMPLEX PLANE Complex Integrals, Cauchy -Goursat Theorem, Independence of Path, Cauchy's Integral Formulas and Their Consequences, Cauchy's Two Integral Formulas, Some Consequences of the Integral Formulas, Applications. Self-Learning Component : Integration and some basic formulae	
MODULE 3	12Hrs
PROBABILITY THEORY Random Variable-Discrete and continuous random variables- Distribution and density function-Properties-Binomial Distribution-Poisson Distribution-Uniform Distribution-Gaussian Distribution-Exponential Distribution-Rayleigh Distribution-Conditional Distribution- Multinomial Distribution Density function-Properties Self-Learning Component : Events, Sample space	
MODULE 4	12Hrs
NUMERICAL METHODS FOR ORDINARY DIFFERENTIAL EQUATIONS Introduction to Numerical methods, Initial and Boundary value problems, Numerical solution of ODE, Picard's method, Taylor's series method, Euler's method, Modified Euler's method, Runge-Kutta method Self-Learning Component : First order ODE and its solving techniques	
MODULE 5	10Hrs
NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS Introduction of PDE, Classification of PDE: parabolic, elliptic and hyperbolic. Boundary and initial conditions, Taylor series expansion, analysis of truncation error, Finite difference method: FD, BD & CD, Higher order approximation, Order of Approximation, Polynomial fitting, One-sided approximation.	

TEXT BOOKS:

1. A First course in complex analysis with applications, Dennis Zill and Patrick Shanahan, Jones and Bartlett publishers.
2. A First Course in Probability, S. Ross, Pearson International Edition, 9th Edition
3. Fundamentals of Mathematical Statistics, S. C. Gupta and V. K. Kapoor, Sultan Chand & Sons, 11th Edition
4. Numerical Methods for Engineers, Chapra and Canale, Mc Graw Hill Education, 7th edition

REFERENCES:

1. Complex Variables and applications, Brown and Churchill, Mc Graw Hill Education, Eighth Edition.
2. Probability, Statistics and Statistics with Reliability, Queuing, and Computer Science Applications, Kishore Trivedi, Prentice Hall, 2nd Edition
3. Probability and Random Processes, S. Miller and Childers, Elsevier Inc., Second Edition
4. Advanced Engineering Mathematics, E. Kreyszig, Wiley, 10th Edition
5. A First Course in Numerical Methods, Ascher and Grief, SIAM 2011

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2302					
TITLE OF THE COURSE	ENGINEERING MATERIALS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

Perquisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course
1			

COURSE OBJECTIVES:

The objectives of the Course are to

- Describe the difference in atomic/molecular structure between crystalline and non-crystalline materials.
- Describe the tensile, compression, shear and bending deformations of the metalspecimen and to describe the changes in specimen profile up to the point of fracture.
- Determine the various phases present, composition and the mass fractions of thephases from a binary phase diagram.
- Name different kinds of steels, cast irons and non-ferrous alloys, and for each cite distinctive properties and typical uses.
- Understand the types and applications of ceramics and polymers.
- Learn the different manufacturing processes for composite materials.
- Familiarize with the testing standards for mechanical characterization

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Classify engineering materials based on their crystalstructure	L2
CO2	Calculate the material properties through testing of materials	L3
CO3	Interpret phase diagram for alloy preparation	L2
CO4	Relate the phase diagram, microstructure and themechanical properties of materials	L3
CO5	Select material for an application by analysing therequirements with the material properties	L1
CO 6	Prepare polymer composites by hand lay-up, vacuumagging, resin transfer moulding and filament winding processes	L3

COURSE CONTENT:

MODULE 1	8Hrs

Introduction to materials, Overview of Crystal Structure, Solid Solutions, Hume Rothery Rules, Crystal Imperfections, Critical nucleus size and Critical Free energy, Mechanism of Crystallization, Nucleation, Nucleation- Growth, Single crystal, Polycrystalline Materials, Basic principles of solidification of metals and alloys. Solidification time, Cooling curves, Non- crystalline solids.

MODULE 2	8Hrs

Testing of materials under tension, compression and shear loads, Hardness tests, fatigue and creep test. Impact testing, Fatigue testing, Fracture, Types, Fracture mechanics. Characteristics of creep curve & steady state creep. Fracture toughness & fatigue, Stress and temperature effects.

MODULE 3	10Hrs

Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Phase Rule, Unary System, Binary Phase diagrams, Iron-carbon system. Phase transformations. Transformation rate effects and Isothermal transformations (TTT Curves), Continuous cooling transformations, Microstructure and property changes in iron- carbon system, Iron-carbon equilibrium diagram, Heat treatments.

MODULE 4	8Hrs

Classification of steels and cast iron, Microstructure, Effect of alloying elements on steel, Ferrous alloys and their applications, High Resistivity and High temperature alloys, Selection of material for various applications- case studies.

MODULE 5	8Hrs

Ceramics, Glass Ceramics, Advanced ceramics, Functional properties and applications of ceramic materials and Glasses, Polymers, Composites, Nanomaterials, Materials used in additive manufacturing.

List of Laboratory/Practical Experiments activities to be conducted : 28Hrs

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|--|
| 1. Tension Test- To understand the tensile characteristics of mild steel through tensile testing and thereby determine mechanical properties such as ultimate tensile strength, elastic modulus, proportionality limit, yield point, fracture stress, percentage elongation & reduction in area. |
| 2. Compression Test- To determine the compressive strength of aluminium and cast-iron specimens and to identify the failure modes of ductile/brittle materials through evaluation of their failure modes of above material. |
| 3. Shear Test - To determine ultimate shear strength of aluminium under single and double shear. |
| 4. Bending Test - To investigate the relationship between load and span on deflection of a simply supported beam subjected to a concentrated load at the centre. Also, evaluate the modulus of elasticity of the given beam from the test data. |
| 5. Impact Test (Charpy and Izod) - To evaluate the energy absorbed during failure of a notched specimen subjected to pendulum impact testing. |
| 6. Brinell hardness Test -To determine the Brinell Hardness Number (BHN) of the given specimens. |
| 7. Vicker's Hardness Test - To determine Vickers Hardness Number for a given specimen. |
| 8. Wear Test - To understand the parameters that affect the wear rate using pin and disc apparatus. |
| 9. Composite preparation- preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process. |
| 10. Demonstration of 3D printing of given polymer/metal/ceramic specimens. |

TEXT BOOKS:

1. William D. Callister, Jr.(2020) “Materials Science and Engineering anIntroduction”, 2nd Edition, John Wiley & Sons, Inc.
- V. Raghavan (2019), “Materials Science and Engineering”, Prentice – Hall of IndiaPvt. Ltd.
2. V. Raghavan (2019), “Materials Science and Engineering”, Prentice – Hall of IndiaPvt. Ltd.

REFERENCES:

1. J.M. Shackelford (2014), Introduction to Materials Science for Engineers, 5thEdition, Prentice Hall, Inc.
2. Suryanarayana, A. V. K. (2020), Testing of Metallic Materials, Prentice Hall India,New Delhi.
3. W. Bolton (2013), Engineering materials technology, 3 rd Edition, Butterworth &Heinemann.

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2303					
TITLE OF THE COURSE	ENGINEERING MECHANICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

The objectives of the Course are to

- Explain different types of forces and couples, resolution of forces and couples, equilibrium conditions and related theorems
- Explain concepts of friction and their relevance in Engineering problems
- Describe centroid, center of gravity and differences between them, area moment of inertia, examples of planar objects and computations for them
- Describe Trusses and its classification, assumptions in analysis of trusses, forces in members in a truss
- Calculate various dynamic quantities of translational motion and projectile motion
- Explain principles of dynamics in plane motion analysis

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Analyze structure using free body diagrams and principle of statics	L3
C02	Analyze structures using concept of equilibrium conditions considering effect of frictional forces	L3
C03	Calculate the centroid and moment of inertia of composite geometrical sections	L3
C04	Compute axial forces in members of determinate truss	L3
C05	Analyze plane kinematics and kinetics of particles/rigid bodies	L3

COURSE CONTENT:

MODULE 1	8Hrs
Introduction to Engineering Mechanics: Force Systems Basic concepts, Particle Equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Resultant- Moment of Forces and its Application; Couples and	

Resultant of force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium.	
MODULE 2	8Hrs
Friction: Introduction, Types of friction, Limiting friction, Cone of Friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, Ladder friction, related problems.	
MODULE 3	10Hrs
Centroid, Centre of Gravity and Moment of Inertia: Introduction, Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone.	
MODULE 4	8Hrs
Analysis of Truss: Introduction, Classification of trusses, Equilibrium in two and three dimension; Method of Sections; Method of Joints; To determine if a member is in tension or compression; Simple Trusses; Zero force members.	
MODULE 5	8Hrs
Dynamics: Introduction, Rectilinear motion; Plane curvilinear motion (rectangular path, and polar coordinates); Projectile motion, Relative and constrained motion; Basic terms, general principles in dynamics; Types of motion, Instantaneous Centre of rotation in plane motion and simple problems; D'Alembert's principle and its applications in plane motion and connected bodies.	

TEXT BOOKS:

1. A. Nelson (2009), Engineering Mechanics: Statics and dynamics, Tata McGraw Hill publications.
2. Irving H. Shames (2006), Engineering Mechanics, 4th Edition, Prentice Hall publications.

REFERENCES:

1. R.C. Hibbler (2006), Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
2. Bansal R.K (2010), A Text Book of Engineering Mechanics, Laxmi Publications.
3. H.J. Sawant, S.P Nitsure (2018), Elements of Civil Engineering and Engineering Mechanics, Technical Publications.
4. www.dsu.edu.in

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2304					
TITLE OF THE COURSE	THERMODYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- Introduce basic concepts related to thermodynamic system
- Understand Zeroth law of thermodynamics as basis for temperature measurement.
- Define first law of thermodynamics as applied to closed and open systems.
- Explain working of heat engine and refrigeration cycles and to define second law of thermodynamics: Kelvin Planck and Clausius Statement.
- Understand the property entropy through Clausius inequality.
- Understand behavior of ideal and real gases through equation of state and compressibility factor.
- Define pure substance and explain salient points involved in phase change, Plot state diagrams for pure substance.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic concepts of thermodynamics	L2
C02	Apply laws of thermodynamics in temperature measurement, work, heat and other energy interactions of different systems	L3
C03	Analyze system performance based on second law implications	L4
C04	Calculate work, heat, change of energy, change of entropy for closed and open systems executing various thermodynamic processes with and without phase change	L3
C05	Differentiate between ideal and real gas behavior and explain the compressibility factor	L2
C0 6	Calculate thermodynamic properties of a pure substance in a given state	L3

COURSE CONTENT:

MODULE 1	10Hrs

Basic Concepts of Thermodynamics: Introduction- Basic Concepts, Thermodynamic Equilibrium, Thermodynamic properties, Thermodynamic state, state point, path and process, quasi-static process, cyclic and non-cyclic processes, Energy and its forms, Work and heat (sign convention), Zeroth Law of Thermodynamics: Zeroth law of thermodynamics statement, Concept of Temperature and its' measurement, Ideal and Real Gases, Gas laws- Boyle's Law, Charles Law, Gay-Lussac Law, Avogadro's law, equation of state - Vander Waals, Redlich-Kwong, Peng- Robinson etc. compressibility factor.	
MODULE 2	8Hrs
First law of thermodynamics: application to closed and open system, Joules experiments, equivalence of heat and work, Internal energy and enthalpy, energy as a property, specific heat at constant pressure and volume, PMM1, steady state, steady flow energy equation (SFEE), extension of first law to control volume, Limitations of first law of thermodynamics, Extension of SFEE to Various devices like-nozzle, turbine, pump/compressor, heat exchanger	
MODULE 3	8Hrs
Second Law Of Thermodynamics: Thermal reservoirs, , devices converting work to heat in a thermodynamic cycle, heat engine, Efficiency reversed heat engine, heat pump, Refrigerator, Coefficient of Performance, Kelvin- Planck and Clausius statement of second law of thermodynamics, Equivalence of the two statements, reversible and irreversible processes, factors that make a process irreversible, Carnot cycle and Carnot engine, Carnot theorem and its corollaries.	
MODULE 4	8Hrs
Entropy : Clausius Inequality:- Statement, proof, application to a reversible cycle, Entropy: Definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility, Tds equation, calculation of entropy using Tds relations, entropy as a coordinate, Exergy(Available) and unavailable energy, Second law efficiency.	
MODULE 5	8Hrs
Pure substance: Phase change process in a pure substance, Definition of triple, ice, steam and critical points, Property diagrams of pure substance, p-v, p-T, p-h, T-v, T-s diagrams, dryness fraction, use of steam tables.	

TEXT BOOKS:

1. P.Nag (2017), Basic & Applied Thermodynamics, 2nd Edition, Mc Graw Hill Education.
2. Van Wylen, G.J., and Sonntag, R.E., (2002), Fundamentals of Classical Thermodynamics for Engineers, 6th Edition, Wiley.

REFERENCES:

1. Yunus A Cengel and Michael A Boles (2017), Thermodynamics: An Engineering Approach, McGraw Hill Education.
2. Michael J. Moran, Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd, Chichester.

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2305					
TITLE OF THE COURSE	COMPUTER AIDED MACHINE DRAWING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	-	4	-	84	4

Perquisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are to

- Provide overview of various CAD software
- Learn basics of sketching features
- Create 3D models using extrude, revolve, draft & other advanced options
- Introduce assembly concepts
- Create simple & complex mechanical assemblies
- Create industrial standard drawings with appropriate views including sectional views

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Discuss different types of CAD tools	L2
CO2	Create 2D geometric sketches by Autodesk FUSION360.	L3
CO3	Develop 3D models of components using basic and advanced features	L4
CO4	Create different types of assemblies using appropriate constraints	L3
CO5	Produce BOM and manufacturing drawings using appropriate views, symbols & tolerances	L2
CO 6	Discuss applications of CAD data exchange formats	L2

COURSE CONTENT:

MODULE 1		10Hrs
CAD Overview: Preferences-Settings, User Interface- Familiarize the User Interface by creating a simple design, Use of toolbar, marking menu, browser and time line controls, change of workspace, Navigations and data panel interface, Design Units and Origin, Quick Shape Creation.		
MODULE 2		10Hrs
Sketching Workspace: Creating a sketching geometries - Introduction to the Sketching Workflow, Sketch Entities, Dimensioning, Sketch Constraints. Additional Sketching		

Tools- Additional Entity Types, Editing Tools, Additional Dimension Tools, Moving and Copying, Rectangular and circular Patterns. Sketched Secondary Features using existing geometry. Pick and Place Features- Fillets, Chamfers, Holes, Editing Pick and Place Features. Construction of planes, axis and points, creating a sketch using Equation and Parameters.	
MODULE 3	12Hrs
Introduction-Solid Modeling techniques: Constructive Solid Geometry using primitives, Boundary representation & Hybrid methods. Basic Part modelling features- Extrude and revolve. Additional Features and Operations- Draft, Shell, Rib, Split Face, Scale, Thread, Press Pull. Design and Display Manipulation- Reordering, inserting, suppressing Features, Measure and Section Analysis, Direct Modeling Development of multi section solids and sweep. Feature Duplication – mirroring and patterning. Develop the part models and prepare the drafting. List out the operations involved to prepare the components.	
MODULE 4	12Hrs
Distributed Design- Assembly Design Methods, Joint Origins and Assigning Joints. Component Design Tools- Rigid Groups, Interference Detection. Multi-Body Design- Multi- Body Design Tools, Components, As-Built Joints. Drawing Basics-Creating a New Drawing, Additional Drawing Views, Exploded Views, Manipulating Drawings. Detailing Drawings- Dimensions, Parts List and Balloons, Annotation and Dimension Settings, Drawing Output. Data exchange standards – IGES, STP, STL, STEP etc. Develop the assembly drawing from the given detailed drawing(Machine components upto five major parts). Indicate the empirical relations along with actual dimensions and bill of materials. Layout the drawings in A3 sheet.	
MODULE 5	40Hrs
Assembly of Machine Parts: Develop the assembly drawing from the given detailed drawing showing conventional representations with geometrical and dimensional constraints. Prepare the bill of materials for the given assembly 1. Swivel bearing 2. Petrol engine connecting rod 3. Cylinder relief valve 4. Machine vice 5. Tailstock 6. Piston of a petrol engine 7. Air valve 8. Fuel Injector 9. Speed reducer 10. Drill jig Layout the drawings in A1 sheet.	

TEXT BOOKS:

1. K. R. Gopalakrishna (2017) "Machine Drawing in First angle projection", Subhaspublication, Bangalore.
2. N.D.Bhat & V.M.Panchal (2016), "Machine Drawing", Charotar Publishing House.

REFERENCES:

1. Basant Agrawal & C M Agrawal (2017) "Engineering Drawing, 2nd Edition ",Mc.Grawhill.

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2306					
TITLE OF THE COURSE	MECHANICAL MEASUREMENTS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

COURSE OBJECTIVES:

The objectives of the Course are to

- Introduce the measurement quantities and measurement standards
- To Study the limits, fits, tolerances and gauges
- Learn the concept of slip gauges and wringing phenomenon
- Study the different types of mechanical and electrical comparators
- Illustrate the linear and angular measurements
- Determine the primary detector-transducers, intermediate signal processing system and terminal systems
- Provide the necessary skills for calibration and testing of different gauges and instruments.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain measurement standards and system	L2
C02	Calculate the uncertainty in measurements	L3
C03	Explain tolerance, limits of size, fits, gauges and the various advancement in laser Interferometers, CMM, Machine Vision Systems	L2
C04	Describe generalized measurement system highlighting various types of sensors, Identify transducers, signal conditioning components, and different types of presentation devices. measurement of temperature, pressure	L2
C05	Calibrate various measuring devices and errors and correction factors of various measuring devices	L2
C0 6	Compute the linear and angular measurements and demonstrate the necessary skills to collect data, perform analysis and interpret results to draw valid conclusions through standard test procedures.	L2

COURSE CONTENT:	
MODULE 1	9Hrs
Standards of Measurements in Meteorology: Definition, objectives and concept of metrology, role of standards, standards of length Principles, light wave length	

standards, subdivision of standards, calibration of standards, numerical problems, slip gauges, set of gauges, wringing phenomena, manufacture of slip gauges. Numerical problems on building of slip gauges, Comparators - mechanical, electrical, pneumatic and optical comparators.	
MODULE 2	9Hrs
System of Limits, Fits, Tolerance and Gauging: Indian standards, concept of limits of size and tolerances, interchange ability, selective assembly definition of fits, hole basis system, shaft basis system, types of fits and their designation, geometric tolerance. Classification of gauges, brief concept of design of gauges (Taylor's principles), Numerical problems Advances in Metrology Basic concept of lasers Advantages of lasers, laser Interferometers. Basic concept of CMM, Types of CMM.	
MODULE 3	8Hrs
Measurement systems and its basic concepts: Definition, significance of measurement, fundamental method of measurements, generalized measurement system, definitions and basic concepts, Linear Measurement and angular measurements. Errors in measuring instruments, classification of errors, sources of errors and uncertainty.	
MODULE 4	8Hrs
Introduction to transducers and intermediate modifying devices: Introduction to Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers, Intermediate modifying devices: Mechanical systems, inherent problems, electrical intermediate modifying devices, input circuitry, ballast circuit, electronic amplifiers. Terminating devices, Cathode ray oscilloscope	
MODULE 5	8Hrs
Temperature and Strain Measurements: Temperature Measurement: Resistance thermometers, thermocouples, laws of thermocouple, materials used for construction, pyrometer, optical pyrometer, Strain Measurement: Theory of strain gauges, types, preparation and mounting of strain gauges, gauge factor, Temperature Compensation, Wheatstone bridge circuit.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs
1. Calibration of Micrometer - To calibrate the given micrometer using slip gauge, draw the calibration curve and to evaluate the errors occurred.
2. Calibration of Vernier caliper and measurement of the given component - To calibrate and measure the given component by using Vernier caliper.
3. Calibration of Thermocouple - To calibrate the given T-Type Thermocouple at different temperatures.
4. Calibration of Linear Variable Differential Transformer (LVDT) - To calibrate the given LVDT (for the performance using Vernier height gauge).
5. Calibration of Load Cell - To calibrate the given Cantilever Beam type load cell.
6. Measurements using Optical Profile Projector - To measure the screw thread parameters of a given specimen using Optical Profile projector.
7. Measurements using Toolmaker's Microscope - To measure the screw thread parameters of a given specimen using Tool Maker's Microscope.

8. Measurements of angle using Sine bar - To determine the unknown angle of the given specimen using sine bar with the help of slip gauge.
9. Measurements of angle using universal bevel protractor - To determine the unknown angle of the given specimen using universal bevel protractor.
10. Measurements of Screw thread parameters using two wire or three-wire methods - To find the effective diameter of a given screw thread by two or three wire method.
11. Measurements of gear tooth profile using gear tooth Vernier caliper - To Measure the tooth thickness of the given gear using Gear Tooth Vernier Caliper.
12. Measurements of Vibrations - To study the vibrations measurement, frequency, displacement, velocity & acceleration.
13. Machine tool alignment test on a) Lathe. b) Drilling machine. c) Milling machine. d) CNC milling.

TEXT BOOKS:

1. Beckwith Marangoni and Lienhard (2006), Mechanical Measurements, Pearson Education, 6th Edition.
2. R.K. Jain (2009), Engineering Metrology, Khanna Publishers, New Delhi.

REFERENCES:

1. S.P. Venkatesh (2008), Mechanical Measurements, ANE Publications
2. Ernest O. Doebelin (2019), Measurement Systems: Application and Design, SIE Publications.

SEMESTER	III					
YEAR	II					
COURSE CODE	20ME2307					
TITLE OF THE COURSE	SPECIAL TOPICS- 1					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	1	-	2	-	42	2

COURSE OBJECTIVES:

- To Student should be aware with current situation and problems of real world.
- Developing critical thinking
- The gap between the current demand and the conventional teaching can be removed.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Improve their understating more towards real problem.	L2
CO2	Solve the subjective problem using latest available technology.	L3
CO3	Understand different perspective of problem solving using software tools	L2
CO4	Prepare documentation for the solution.	L2

COURSE CONTENT:

Online Mooc Courses
Matlab On ramp Certification for basic Matlab.
Mini Project under the guidance of faculty member
Hackathon
Seminar on Mooc courses and project undertaken.

IV SEM - MECHANICAL ENGINEERING

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2401					
TITLE OF THE COURSE	APPLIED THERMODYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

COURSE OBJECTIVES :

The objectives of the Course are to

- Understand Gas power cycles like Otto, Diesel, Dual and Brayton cycles and calculation of heat, work interactions and thermal efficiency
- Understand Vapour power cycles and calculation of heat, work interactions and thermal efficiency
- Understand the effect of inlet pressure and temperature on the performance of vapour power cycles
- Understand the operation of combined cycle with topping gas turbine and bottoming steam cycle
- Explain the working of a single stage and multistage compressor and to calculate work done, volumetric-isothermal-polytropic efficiencies
- Understand refrigeration cycle and calculation of COP and to study different types of refrigerants and to appreciate the use of eco-friendly refrigerants
- Study combustion thermodynamics of fuels
- Carry out tests to investigate the performance of internal combustion engines

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Calculate work obtained, mean effective pressure and thermal efficiency for Otto, Diesel, Dual and Bryton cycles, Thermal efficiency of Basic, modified, reheat and regenerative Rankine cycles	L3
CO2	Calculate the work done and efficiency for single stage and multistage compressor	L3
CO3	Analyze different refrigeration and air-conditioning cycles	L3
CO4	Analyze combustion thermodynamics of fuels	L3
CO5	Estimate the properties of fuels and lubricants like flash and fire point, viscosity and calorific value.	L2
CO6	Predict I C engine performance parameters at different operating conditions and also to carry out heat balance	L3

COURSE CONTENT:	
MODULE 1	8Hrs
Gas Power Cycles Review of thermodynamics laws, Carnot, Otto, Diesel and Dual Cycles; simple Gas turbine cycle (Brayton cycle) and Modifications; Multistage compression with intercooling, Regeneration, reheat cycles practical gas turbine, cycles; Jet Propulsion cycles	
MODULE 2	10Hrs
Vapour Power Cycles and Combined cycle power plants Components of steam power plant, Carnot vapour power cycles, limitation of Carnot cycle, Simple Rankine cycle; Effect of pressure and Temperature on performance of Rankine Cycle, Comparison of Carnot and Rankine cycles. Effects of pressure and temperature on Rankine cycle performance. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, feed water heaters. Reheat Rankine cycle, Supercritical Rankine cycle, combined gas and vapour cycle power plants. Numerical	
MODULE 3	8Hrs
Reciprocating Compressors Classification; work done in a single stage compressor; efficiency; p-v diagram for an actual compressor and diagram factor; multistage compressor; Multistage compressor with intercooler, Performance parameters for reciprocating compressors	
MODULE 4	8Hrs
Refrigeration and Air conditioning Vapour compression refrigeration system; description, analysis, refrigerating effect. Capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties, alternate Refrigerants. Vapour absorption refrigeration system. Psychrometric: Nomenclature, Definition, use of Psychrometric chart, Introduction to air conditioning, different types of air-conditioning systems	
MODULE 5	8Hrs
Combustion Thermodynamics Theoretical (Stoichiometric) air for combustion of fuels. Excess air, mass balance, Exhaust gas analysis, A/F ratio. Energy balance for a chemical reaction, enthalpy of formation, enthalpy and internal energy of combustion. Combustion efficiency. Dissociation and equilibrium, emissions.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :
28Hrs
Determination of Flash point and Fire point of lubricating oil using Abel, Pensky and Marten's (closed) / Cleavland's (Open Cup) Apparatus.
Determination of Calorific value of solid, liquid and gaseous fuels.
Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers.
Valve Timing/port opening diagram of an I.C. engine (4 stroke/2 stroke).

Performance Tests on I.C. Engines, Calculations of IP, BP, Thermal Efficiencies, Volumetric efficiency, Mechanical efficiency, SFC, FP, A-F Ratio, heatbalance sheet.

TEXT BOOKS:

1. Kadambi, T. R Seetaraman and K. B Subramanya Kumar (2019), Applications of Thermodynamics, Wiley India Private Ltd, New Delhi.
2. Nag P.K (2017), Basics and applied thermodynamics, Second edition, Tata McGrawHill, New Delhi.

REFERENCES:

1. Yunus A Cengel and Michael A Boles (2017), Thermodynamics: An Engineering Approach, McGraw Hill Education.
2. Michael J. Moran and Howard N. Shapiro (2006), Fundamentals of Engineering Thermodynamics, John Wiley & Sons Ltd.

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2402					
TITLE OF THE COURSE	MECHANICS OF MATERIALS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1		-	42	3

COURSE OBJECTIVES :

The objectives of the Course are to

- Explain mechanical properties of materials, Stress, Strain and Hooke's law
- Explain principal stresses, maximum shear stress, principal planes and Mohr's circle for plane stress conditions
- Draw shear force and bending moment diagrams in beams to estimate maximum shear forces and bending moment
- Explain torsional moment of resistance, power transmission of straight and stepped shafts, twist in shaft sections
- Explain strain energy due to axial, shear, bending, torsion and impact load
- Explain theories of failure as applied to materials
- Explain mechanical properties of materials, Stress, Strain and Hooke's law
- Explain principal stresses, maximum shear stress, principal planes and Mohr's circle for plane stress conditions

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Calculate stress and strain for different geometries under different loading conditions	L3
C02	Illustrate principal stresses, maximum shearing stress acting on a structural member using analytical and Mohr's circle method	L2
C03	Calculate the stresses and strains associated with thin and thick cylindrical pressure vessels under axial and circumferential loads	L3
C04	Construct shear force and bending moment diagrams for statically determinate beams	L3
C05	Calculate the shear stress for bodies subjected to torsion and bending stresses for columns	L3
C06	Discuss theories of failure as applied to materials	L2

COURSE CONTENT:	
MODULE 1	8Hrs

Stress and Strain	
Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them. Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change.	
MODULE 2	10Hrs
Analysis of Stress and Strain	
Compound Stresses: Principal stresses and maximum shear stress, Planes of Principal stress and Maximum Shear stress, Normal stress on the planes of maximum shear stress, Mohr's circle for plane stress conditions.	
Cylinders: Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, thin spherical Shell, thin cylinder with spherical ends. Thick cylinders: Lamé's theory.	
MODULE 3	8Hrs
Shear Forces and Bending Moments	
Shear Forces and Bending Moments: Type of beams, Loads and reactions, Relationship between loads, Shear force and bending moments of cantilever, simply supported and overhanging beams subjected to concentrated loads and uniformly distributed constant / varying loads.	
Stress in Beams: Bending Theory, Bending and shear stress distribution in rectangular, I and T section beams.	
MODULE 4	8Hrs
Torsion	
Torsion: Circular shafts, Power Transmission, Torsion of tapered shaft, Shafts in series and Parallel, Thin Tubular and Thin-walled sections.	
Columns: Euler's theory, Equivalent Length, Limitations of Euler's Formula, Rankine's Formula	
MODULE 5	8Hrs
Strain Energy	
Strain Energy: Strain energy due to axial, shear, bending, torsion and impact load, Castigliano's theorem and their applications.	
Theories of Failure: Introduction, maximum principal stress theory (Rankine's theory), Maximum shearing stress theory (Guest's and Tresca's theory), maximum principal strain theory (St. Venant's theory), Maximum Strain energy theory (Haigh's Theory) and Maximum Shear Strain Energy Theory (Mises' and Henkeys's Theory)	

TEXT BOOKS:

1. Stephen Timoshenko (2002), Strength of Materials, 3rd Edition, CBS Publisher.
2. S. S. Bhavikatti (2017), Mechanics of Solids, New Age International Publications.

REFERENCES:

1. F. P. Beer and E. R. Johnston (2020), Mechanics of Materials, 8th Edition, McGraw Hill publications.
2. R. K. Bansal (2010), A Textbook of Strength of Materials, 4th Edition, Laxmi Publications.

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2403					
TITLE OF THE COURSE	FLUID MECHANICS AND MACHINES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

COURSE OBJECTIVES:

The objectives of the Course are to

- Define basic properties of fluids and understand the continuum approximation.
- Define kinematics of Fluid Flow
- Describe Lagrangian and Eulerian Approach for fluid flow
- Buckingham's Pi theorem
- Apply dimensional analysis to design new pumps or turbines that are geometrically similar to existing pumps or turbines
- To study the performance parameters of Reciprocating, Centrifugal and Gear pumps
- To study the performance parameters of Impulse and Reaction turbines like Pelton wheel turbine, Francis turbine and Kaplan turbine
- Define basic properties of fluids and understand the continuum approximation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Define fluid, fluid properties and express fluid properties in terms of various measurable parameters	L1
C02	Explain fluid dynamics and develop relevant fluid dynamic relations considering continuity, momentum and energy equations, apply the relations for analysis of dynamic forces and flow through various geometries	L2
C03	Apply concepts of dimensional analysis to develop mathematical relations for various fluid flow situations	L3
C04	Explain working principles of hydraulic turbomachinery and calculate the power and efficiencies involved in operations of machines and learn concepts of compressible flow	L2
C05	Calculate flow rates of fluids using Orifice meter, Venturimeter, Notches, Rotameter, losses in pipe	L3
C06	Study the performance parameters of Reciprocating, Centrifugal and Gear pumps, Impulse and Reaction turbines like Pelton wheel turbine, Francis turbine	L1

COURSE CONTENT:	
MODULE 1	8Hrs
Fluid Properties and Fluid Statics	
Introduction, properties of fluids, viscosity, thermodynamics properties, surface tension and capillarity, vapour pressure. Types of fluid flows Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmospheric and vacuum pressures, Fluid Statics: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid.	
MODULE 2	10Hrs
Fluid Kinematics and Dynamics	
Fluid Kinematics- Introduction, Lagrangian and Eulerian Approach for fluid flow, Continuity equation Velocity and acceleration in a flow field, Potential and stream function, Fluid Dynamics	
Introduction, Equation of motion, Euler's equation of motion, and Bernoulli's equation derived from fundamental & Euler's equation, Bernoulli's equation for real fluids. Fluid Flow measurements-Venturimeter, orifice meter and Pitot tube. Flow through Pipes-Major & Minor losses in pipe flow. Numerical exercise.	
MODULE 3	8Hrs
Dimensional Analysis and Boundary Layers	
Introduction, Dimensional homogeneity –Buckingham theorem – Non-dimensional numbers – Model laws; Unit Quantities and Specific quantities, introduction to boundary layer theory –Laminar flow and Turbulent flow – Boundary layer thickness.	
MODULE 4	8Hrs
Hydraulic Turbines	
Euler's Turbine equation, Classification of turbines, Impulse and reaction turbines, Pelton wheel, Francis and Kaplan turbine –work done and efficiencies. Draft tube theory, Performance of hydraulic machines, unit and specific quantities, turbine governing.	
MODULE 5	8Hrs
Pumps	
Classification, working, work done – monometric head- losses and efficiencies- specific speed- pumps in series and parallel-performance characteristic curves, NPSH. Reciprocating pumps: Working, Discharge, slip.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :
28Hrs
1. Rotameter
Calculation of the Rate of Flow Using Rotameter
2. Venturimeter
Determination of the Co- Efficient of Discharge of the Venturimeter

3. Orifice Meter
Determination of the Co-Efficient of Discharge of the Given Orifice Meter
4. Pipe Friction
Determination of frictional loss in a pipe flow
5. Pipe Fittings
Determination of Loss of Head on Pipe Fittings
6. Notch
Determination of Co- efficient of Discharge of the Given Notch
7. Centrifugal Pump
Study of Performance Test On Centrifugal Pump
8. Reciprocating Pump
Study of Performance Test On Reciprocating Pump
9. Gear Pump Test Rig
Study of Performance Test On Gear Pump
10. Pelton Wheel Turbine
Study of Performance Test on Pelton Wheel Turbine
11. Francis Turbine
Study of Performance Characteristics Curves of Francis Turbine

TEXT BOOKS:

1. Bruce R. Munson, Donald F. Young, Theodore H. Okiishi, Wade W. Huebsch (2009)
2. Fundamentals of Fluid Mechanics, John Wiley & Sons Publications. Frank M White (2011),
3. Fluid Mechanics, McGraw-Hill Publication, Seventh Edition

REFERENCES:

1. Jagdish Lal (2016) , Hydraulic Machines, Metropolitan Company book company Limited
2. Yunus A. Cengel, John M. Cimbala (2006), Fluid Mechanics– Fundamental and Applications, Tata McGraw-Hill Publishing Co. Ltd.

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2404					
TITLE OF THE COURSE	MANUFACTURING PROCESS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

COURSE OBJECTIVES:

Theory component:

- To emphasize the importance of manufacturing sciences in the day-to-day life, and to study the basic manufacturing processes.
- To have a broad knowledge on casting process for a given product.
- To understand the importance of metal forming process.
- To understand basic manufacturing processes like casting and welding process.
- To introduce the concepts of powder metallurgy in manufacturing process.
- To identify, discuss, and analyse the manufacturing processes for processing of plastics.
- To impart knowledge and skills to use tools, machines, equipment, and measuring instruments
- To provide knowledge of various casting process in manufacturing.
- To impart knowledge of joining process used in manufacturing.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain significance and engineering applications of various casting processes	L1
C02	Interpret foundry practices like pattern, mold and core making required for Casting process	L2
C03	Differentiate various metal forming processes such as Hot and Cold Working, Rolling, Forging, Extrusion and Drawing Processes	L2
C04	Choose appropriate joining processes for a given application	L3
C05	Construct different types components using casting, welding and smithy shop	L3
C06	Explain working principle and engineering applications of various manufacturing processes.	L1

COURSE CONTENT:

MODULE 1	08Hrs
CASTING PROCESS	

05 hrs

Casting- Introduction, Advantages and applications; Principle of casting processes – Sand casting, Centrifugal casting, pressure die casting, Investment casting, stir casting, solidification of casting, Gating-Principles, requirements and types, Riser – Function, types, design, Defects in castings. Patterns – Types, making, materials and allowances.

MODULE 2

08Hrs

METAL FORMING

Hot working & cold working, plastic deformation, yield criteria, strain hardening, recovery, recrystallization and grain growth. Rolling types & process, drawing types, sheet forming types & process, Extrusion process types, Forging Processes- classification & types- Power forging, Impression die forging, press forging, upset forging, defects in forging.

MODULE 3

10Hrs

WELDING PROCESS

Welding process: Classification, morphology of fusion weld, working principle, Fusion welding: Arc welding- Gas Metal Arc Welding (MIG), Gas Tungsten Arc Welding (TIG), Shielded Metal Arc Welding (SMAW), plasma arc welding, oxyfuel gas welding, Resistance welding- spot, seam, projection, Solid state welding: Friction, friction stir welding, ultrasonic welding, forge welding, electromagnetic pulse welding, hot isostatic pressure welding, Laser welding, Electron beam welding, thermit welding.

MODULE 4

08Hrs

POWDER METALLURGY

Introduction & applications, basic steps, methods of manufacturing powders- Physical, Chemical, Mechanical & Nano powder production methods, mixing of powders, compaction- Pressure less and pressure compaction, explosive compaction, sintering methods, post sintering process, Defects in Powder metallurgy, Characteristics and testing of Metal Powders.

MODULE 5

08Hrs

PROCESSING OF PLASTICS

Classification of Polymers, Forms of raw plastic material, Types and characteristics of plastics, methods of processing plastics, moulding of thermoplastics – working principles and applications, compression moulding, Transfer Moulding, blow moulding, rotational moulding, Film blowing, Thermoforming.

**List of Laboratory/Practical Experiments activities to be conducted (if any) :
28Hrs**

1. **Foundry shop:** Testing of Moulding sand and Core sand - Tensile Strength Test for Core Sand, Compression Test of Molding Sand, Shear Test of Moulding Sand, Permeability Test, Grain Fineness Test, Clay Content Test, Moisture Content Test, Mould Hardness Test, Foundry Model- Preparation of green sand moulds using two

molding boxes kept ready for pouring- Using patterns (Single piece pattern and Split pattern) & without patterns =
2. Forging Operations: Involving upsetting, drawing and bending operations, Simple exercises involving the fabrication of square & hexagonal bolts.
3. Welding shop: Gas welding & Arc Welding
4. Powder Metallurgy: To perform powder compaction of different metal powder by hydraulic press & study the mechanism of sintering (Demo)
5. Industrial Visit- Report making

TEXT BOOKS:

1. P.N. Rao. Manufacturing Technology: Foundry, Forming and Welding, McGrawHill Publication, 5th Edition. (2018)
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 7th Edition, John Wiley & Sons, Inc, New Jersey. (2019)

REFERENCES:

1. Amitabha Ghosh and Asok Kumar Malik (2010), Manufacturing Science, Affiliated East-West Press Ltd.
2. J. T. Black and Ronald A. Kohser (2019) De Garmos Materials and Processes in Manufacturing, John Wiley & Sons, Inc, New York.

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ENC001					
TITLE OF THE COURSE	ECONOMICS FOR ENGINEERS					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	02			-	28	2

COURSE OBJECTIVES:

The objectives of the Course are to

- Understand the importance of economics in engineering decisions as well as day-to-day life and identify various factors of production
- Calculate compound interest, effective interest, nominal interest and the inflation value
- Draw the cash-flow diagram of a firm, calculate their present worth and equivalent annual worth
- Discuss capital budgeting, payback period method, account rate of return method, benefit/cost analysis
- Discuss net present value method, internal rate of return and return on investment
- Explain replacement criteria such as deterioration, obsolescence, inadequacy and cyclic replacements

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the relevance of economics in engineering manufacturing environment.	L1
CO2	Determine the time value of money	L2
CO3	Determine the present worth and equivalent annual worth of the firm's assets and investments.	L2
CO4	Assess the available economic alternatives using traditional and discounted cash flow methods	L3
CO5	Calculate the depreciation value of equipment using different methods	L3
CO6	Perform break-even analysis for a manufacturing company	L3

COURSE CONTENT:

MODULE 1	04Hrs
Basic Concepts of Engineering Economics	

Introduction to Engineering economics, Engineering decision makers, engineering and economics, problem solving and decision making, strategy and tactics, factors of production, Production possibility schedule and curve, marginal rate of transformation, Concept of economic growth	
MODULE 2	03Hrs
Time Value of Money Time value of money - Simple interest, compound interest – nominal interest rate, effective interest rate, and inflation.	
MODULE 3	07Hrs
Present Worth and Equivalent Annual-Worth Comparisons Present worth calculations, Equivalent Annual worth Comparison methods, Situations for Equivalent Annual worth Comparison, Consideration of asset life, comparison of assets with equal and unequal lives.	
MODULE 4	07Hrs
Economic Evaluations Introduction, capital budgeting, importance of capital budgeting, Traditional and discounted cash flow methods of capital budgeting – payback period method, accounting rate of return method, profitability index, net present value method, internal rate of return, Benefit/Cost Analysis, return on investment. break-even analysis	
MODULE 5	07Hrs
Replacement Analysis and Depreciation Replacement due to deterioration, obsolescence, inadequacy, Economic life for cyclic replacements, Depreciation, Causes of Depreciation, Basic methods of computing depreciation charges, Use of sinking fund method.	

TEXT BOOKS:

1. Riggs, J., Bedworth D., & Randhawa S., (2011), Engineering Economics, 4th Edition, McGraw-Hill Education
2. Pindyck, R. S., & Rubinfeld, D. L. (2015), Microeconomics, 7th edition, Pearson Education India

REFERENCES:

1. Panneerselvam R, (2013), Engineering Economics, 2nd edition, Prentice Hall India Learning Private Limited

SEMESTER	IV					
YEAR	II					
COURSE CODE	20ME2405					
TITLE OF THE COURSE	SPECIAL TOPICS-II					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	01	-	02	-	42	02

COURSE OBJECTIVES:

Theory component:

- Student should be able to solve real world problem
- Student should be aware with more recent technologies.
- Developing Collaborative Learning, Communication skills.
- Student should be able to solve problems in core and intra/inter/multi-disciplinary areas.
- Developing critical thinking and communication skills.
- The gap between the current demand and the conventional teaching can be removed.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Improve their understating more towards real problem.	L2
CO2	Solve the subjective problem using latest available technology.	L3
CO3	Understand different perspective of problem solving.	L2
CO4	Understand the subjective application in different inter/intra/multidisciplinary areas.	L2

COURSE CONTENT:

Online Mooc Courses	
Matlab On ramp Certification for basic Matlab, Machine learning and Deep Learning.	
Mini Project under the guidance of faculty member	
Hackathon	
Seminar on Mooc courses and project undertaken.	

V SEM - MECHANICAL ENGINEERING

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3501					
TITLE OF THE COURSE	Heat Transfer					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	III	20ME2304	Thermodynamics

COURSE OBJECTIVES:

- To understand the basic phenomenon of heat transfer and its importance in engineering applications.
- To enable the students to understand the different modes of heat transfer like conduction, convection and radiation.
- To understand the mechanism of heat transfer under steady and transient conditions
- To illustrate the applications of convective heat transfer including heat exchangers, boiling & condensation
- To understand the different laws of radiation and applying for solving engineering problems

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Compute temperature distribution and heat flow in steady-state and unsteady-state 1-D heat conduction	L3
C02	Calculate forced and free convective heat transfer coefficient and rate of heat transfer	L3
C03	Analyze performance characteristics of heat exchangers	L4
C04	Calculate radiation heat transfer between objects with simple geometries	L3
C05	Demonstrate conduction, convection, and radiation heat transfer phenomena through experiments	L2

COURSE CONTENT:	
MODULE 1	08 Hrs

Modes of heat transfer: Basic laws governing conduction, Thermal conductivity. Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, discussion on 3-D conduction in cylindrical and spherical coordinate system. One dimensional conduction equations for plane, cylinder and spheres. Overall heat transfer coefficient, Thermal conductive resistance and numerical problems. Derivation for heat flow and temperature distribution in a plane for variable thermal conductivity case, critical thickness of insulation and numerical problems.	
MODULE 2	08 Hrs
Introduction, Heat transfer through rectangular fin, infinitely long fin, short fin with insulated tip and without insulated tips. FIN efficiency and effectiveness. Numerical problems. Transient Conduction: Lumped parameter analysis, use of transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, numerical problems	
MODULE 3	10 Hrs
Natural Convection: Introduction, laminar flow, momentum and energy equations for vertical flat plate, physical significance of Grashoff number, use of correlations for free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, numerical problems. Forced Convection: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems.	
MODULE 4	08 Hrs
Fundamental concepts of radiation, different laws governing radiation heat transfer, Stefan-Boltzman law, Kirchoff's law, Planck's law, Wein's displacement law, Intensity of radiation and Lambert's cosine law, Radiation shape factor, Heat exchange by radiation between two black and diffuse gray surfaces, radiation shields, numerical problems.	
MODULE 5	08 Hrs
Heat exchangers: Classification and applications, overall heat transfer coefficient, heat exchanger analysis-Logarithmic mean temperature difference for parallel and counter flow heat exchanger, effectiveness-number of transfer units, method for parallel and counter flow heat exchanger, introduction to cross flow heat exchanger, Logarithmic mean temperature difference correction factor. Numerical problems. Condensation and Boiling: Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation. (no numerical problems).	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Determination of thermal conductivity of metal rod.
2.	Determination of thermal conductivity of composite wall.
3.	Experiment on transient conduction heat transfer.
4.	Determination of heat transfer coefficient in natural convection.
5.	Determination of heat transfer coefficient in forced convection.

6.	Determination of temperature distribution, fin efficiency in natural / forced Convection.
7.	Determination of emissivity of a test surface.
8.	Determination of the emissive power of black body using Stefan's Boltzmann's constant.
9.	Determination of effectiveness and logarithmic mean temperature difference in parallel flow and counter flow heat exchanger.

TEXT BOOKS:

1. Incropera, F.P. and DeWitt, D.P(2011). "Fundamentals of Heat and Mass transfer , John Wiley

REFERENCES:

1. Ozisik(2002.), Heat Transfer-A Basic Approach, Tata Mc Graw Hill.
2. P K Nag (2011), Heat and Mass Transfer, Tata McGrawHill
3. J P Holaman (2009), Heat Transfer, Tata McGrawHill.
4. C.P. Kothandraman, S. Subramanyan(2014), Heat and Mass Transfer Data Book, New Age International Publishers,

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3502					
TITLE OF THE COURSE	Kinematics and Theory of Machines					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	--	-	56	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To impart knowledge on the kinematics and dynamics of planar mechanisms
- analyze the bodies which is in motion using the basics of kinetics and kinematics
- To determine the balancing of masses of rotating and reciprocating machine elements
- To understand the principles of cams, governors and gyroscope
- To familiarize various mechanism by modeling and simulating the final motion in 3D modeling software
- To be able to make completely balanced systems by identify the angular position and spacing between each masses
- To distinguish the performance of different governors by characterize effort, power and sensitiveness
- To understand the gyroscopic principle and verifying its effect by changing the torque

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Discuss the fundamentals of various mechanisms and its inversion	L2
CO2	Perform velocity and acceleration analysis of a particle in a given system and angular velocity of rigid bodies that are in plane motion.	L3
CO3	Solve the problems related to balancing the parts in rotating and reciprocating systems	L3
CO4	Apply the principles of balancing of masses to various systems and engines	L3
CO5	Construct the cam profile for a desired motion. Recognize the fundamentals of governor and gyroscope	L3

COURSE CONTENT:	
MODULE 1	12Hrs
Definitions Link or element, kinematic pairs, chain, Mechanism and Structure, Degrees of freedom, Grubler's criterion. Inversions of various mechanisms. Quick return motion Mechanisms. Straight line motion mechanisms. Intermittent Motion mechanisms. Toggle mechanism, Pantograph, Steering gears mechanism. Universal Hooke's Joint.	
MODULE 2	12Hrs
Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism. Relative velocity and acceleration of particles in a common link and coincident Particles on separate links- Coriolis component of acceleration. Velocity Analysis by Instantaneous Center Method. Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism.	
MODULE 3	12Hrs
Introduction, Static equilibrium. Equilibrium of two and three force members, members with two forces and torque, free body diagrams. Principle of virtual work, static force analysis of various mechanisms with and without friction. Dynamic Force Analysis: D'Alembert's principle, inertia force and torque. Dynamic force analysis of four-bar and slider crank mechanism.	
MODULE 4	10Hrs
Static and dynamic balancing. Balancing of single and several rotating mass. Balancing of single cylinder engine: multi cylinder-inline engine (primary & secondary forces), V-type engine. Balancing of locomotives	
MODULE 5	10Hrs
Types of cams and followers. Development of cam profile for various types of follower and its different motion. Governors: Types of governors; governor characteristics, force analysis of centrifugal governors. Gyroscope: Vector representation of angular motion. Gyroscopic couple, effect of gyroscopic couple on ship, plane disc, aeroplane,	

TEXT BOOKS:

1. Theory of Machines, Rattan S.S, Tata McGraw-Hill Publishing Company Ltd., New Delhi,

REFERENCES:

1. Theory of Machines & Mechanisms, J.J. Uicker, G.R. Pennock, J.E. Shigley. Oxford University Press, 4th Edition, 2010.
2. Theory of Machines, Thomas Bevan, CBS Publication 3rd Edition, 2005.
3. Theory of Mechanisms and Machines: Amitabha Ghosh and Ashok kumar Mallik, 3rd Edition Affiliated East-West Press.1976.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3503					
TITLE OF THE COURSE	Design of Machine Elements-1					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	III	20ME2302	ENGINEERING MATERIALS

COURSE OBJECTIVES:

- Understand the stresses in machine members due to various types of loads and failure of components according to theories of failures.
- Analyze the components under variable loading for infinite and finite life.
- Design of machine elements under torsion, bending, axial loads and a combination of these.
- Design of permanent and temporary joints and fasteners for a given load to be transmitted.
- Design of various screws, keys, coupling and shafts.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Classify various stresses acting on a machine element	L2
CO2	Compute the dimensions of component based on the concepts of failure theories	L3
CO3	Interpret different kinds of loading in mechanical engineering components	L3
CO4	Quantify factor of safety, failure modes for mechanical components subjected to direct and bending and combined loading	L3
CO5	Choose the appropriate keys, coupling, shafts and joints in the design of machine components	L2

COURSE CONTENT:	
MODULE 1	10Hrs

Normal, shear, biaxial and triaxial stresses, stress tensor, principal stresses. Stress-strain diagrams, stress analysis. Design considerations: Codes and standards, design stress, factor of safety, stress concentration factor in tension, bending and torsion, theories of failures, Static Strength: Static loads, Impact Strength: Introduction, impact stresses due to axial, bending and torsional loads, effect of inertia, Failure of brittle and ductile materials	
MODULE 2	08Hrs
Introduction, S-N Diagram, low cycle fatigue, high cycle fatigue, endurance limit, modifying factors: size effect, surface effect, stress concentration effects, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.	
MODULE 3	08Hrs
Threaded fasteners: Stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints. Riveted and Welded Joints: Types, rivet materials, failures of riveted joints, joint efficiency, boiler joints, riveted brackets. Welded Joints: Types, strength of butt and fillet welds, eccentrically loaded welded joints.	
MODULE 4	08Hrs
Joints: Types of keys, design of socket-spigot cotter joint, design of knuckle joint. Couplings: Types of couplings, design of flange and flexible couplings and muff coupling	
MODULE 5	08Hrs
Shafts: Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under fluctuating loads and combined loads. Curved Beams: Stresses in curved beams of standard cross sections used in crane hook	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs	
1.	Determination of principal stresses and strains in a member subjected to combined loading using strain rosettes and verification using FEA tool.
2.	Determination of critical speed of a rotating shaft and verification using FEA tool.
3.	Determination of stresses in curved beam using strain gauge and verification using FEA tool.
4.	Design of Shafts subjected to direct and combined loading for given loads and conditions and comparing design by using CAD/CAE software.
5.	Determination of Fringe constant of Photo-elastic material using. a) Circular disc subjected to diametric compression. B) Pure bending specimen (four point bending)

TEXT BOOKS:

1. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.
2. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

REFERENCES:

1. Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.
2. M. F. Spotts, T. E. Shoup, L. E. Hornberger, S. R. Jayram and C. V. Venkatesh, Design of Machine Elements Pearson Education, Eighth edition 2019.
3. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.
4. R S Khurmi and J K Gupta, A Textbook on Machine Design, S Chand Publications, Fourteenth Edition 2005.
5. K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.
6. K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3504					
TITLE OF THE COURSE	Manufacturing Technology					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To understand the basic fundamentals and mechanics of metal cutting, tool geometry and life.
- To know the basic knowledge of various machine tools, classification, specification, operations of each machining process like turning, milling, drilling, shaping and grinding operations.
- To impart knowledge on Non-Traditional & CNC machining operation
- To understand the fundamentals of various additive manufacturing technologies for application to various industrial needs

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Choose appropriate machine tools for various machining operations	L3
CO2	Identify traditional machining processes for turning, milling, drilling and grinding operations	L3
CO3	Classify non-traditional machining processes for advanced machining applications	L2
CO4	Analyse working features of CNC machines and part programming	L3
CO5	Describe the methods for manufacture of products using 3D Printing technologies	L2

COURSE CONTENT:	
MODULE 1	08Hrs
Types of cutting tool materials, cutting fluids, Single & Multi point cutting tool nomenclature, orthogonal and oblique cutting, mechanism of chip formation, types of chip, merchant analysis, Ernst-merchant's solution, shear angle relationship, problem of merchant's analysis, tool wear and tool failure effects of cutting parameters, tool life criteria, Taylor's tool life equation, problems.	

MODULE 2	08Hrs
Lathe Machine: Classification, features, driving mechanisms of lathe and operations on lathe. Drilling machine: Classification, features & operations. Milling: Classification, features, operations, up and down milling, Indexing concepts. Grinding: Types of abrasives, bonding process, structure & types of grinding wheels	
MODULE 3	10Hrs
Introduction, Classification, Abrasive jet machining, Ultrasonic machining, Water jet machining, Abrasive Water Jet Machining, Electro chemical machining, Electro Chemical Grinding, Electro-discharge machining, Laser beam machining, Electron Beam Machining, Chemical Milling, Photochemical Milling process characteristics – applications, advantages and disadvantages.	
MODULE 4	08Hrs
Fundamentals of numerical control, advantages & classification of NC systems, Functions of MCU, principles of operation features, functions of CNC, Manual part programming, Codes and concepts, point to point and contour programming examples, 2-D simple problems of Drilling, Turning and Milling.	
MODULE 5	08Hrs
Introduction, Prototyping fundamentals, Classification, applications, 3D modeling, Data Conversion and transmission, Post processing, RP data formats, Introduction on liquid, solid and powder based additive manufacturing systems, Case studies.	

List of Laboratory/Practical Experiments activities to be conducted (if any) : 28Hrs	
1.	To Study of Mechanism in Lathe and Perform Various Operations on a Lathe Machine.
2.	To study tool wear and tool life measurements for machinability
3.	To Study Construction, Working and Performing Operations on a Drilling & Grinding Machine.
4.	To Study Construction and Working of Milling Machine
5.	To Study Construction, Working and Perform of Shaping Operation on a Shaper Machine.
6.	Introduction of Computer Numerical Control Machines and working of few Models on CNC machine.
7.	Study the mechanism and working of 3D Printing machine.

TEXT BOOKS:

1. Serope Kalpak Jain and Steven R. Schmid, "Manufacturing Engineering and Technology", 7th Edition, Prentice Hall, 2018.

2. P.N. Rao, "Manufacturing Technology – Metal Cutting and Machine Tools,"Volume-II,4 Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2018.

REFERENCES:

1. M. P. Groover, "Fundamentals of Modern manufacturing" -materials, processes and systems Third Edition, Wiley publications, 7th Edition, 2019.
2. Kaushik Kumar, Chikesh Ranjan and Paulo Davim, CNC Programming for Machining, Springer International Publishing, 2020.
3. Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies- 3D printing, rapid prototyping, direct digital manufacturing", Springer International Publishing, 2019.

SEMESTER	V					
YEAR	III					
COURSE CODE	20EME3505					
TITLE OF THE COURSE	Special Topics - III					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	-	-	-	28	2

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- Student should be able to solve problems in core and intra/inter/multidisciplinary areas
- Student should be aware with current technologies
- Developing critical and creative thinking.
- Work in team environment to develop communication skills

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Define problems in core and interdisciplinary and multidisciplinary areas	L2
C02	Solve the subjective problem using current technologies	L3
C03	Demonstrate the interdisciplinary/multidisciplinary approach.	L4
C04	Prepare documentation for the solution.	L3

COURSE CONTENT:	
MODULE 1	12Hrs
Introduction to Python Programming and solving subjective problems.	
MODULE 2	10Hrs
Project under the guidance of faculty members on current semester subjects.	
MODULE 3	10Hrs
Solving subjective problem using software tools (Ansys, Catia, fusion 360)	
MODULE 4	10Hrs
Seminar on projects undertaken.	

PROFESSIONAL ELECTIVE – I

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3506					
TITLE OF THE COURSE	INTRODUCTION TO ROBOTICS AND AUTOMATION					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To introduce the basic concepts, parts and types of robots.
- To make the student familiar with the various sensors, drive systems in robots and programming.
- To discuss about the various applications, justification and implementation of robot.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic principles of Robotic technology, configurations, control and programming of Robots	L2
C02	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
C03	To choose the appropriate Sensor and Machine vision system for a given application	L3
C04	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
C05	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material	

transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	08Hrs
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	08Hrs
Drive system, control system, robot drive mechanisms, hydraulic - electric - servomotor- stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	08Hrs
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	08Hrs
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS:

1. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES:

1. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004..
2. Richard D. Klafter, Robotic Engineering, Prentice Hall of India Pvt., Ltd., 2001.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3507					
TITLE OF THE COURSE	FUNDAMENTALS TO MACHINE LEARNING & ARTIFICIAL INTELLIGENCE					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	--	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES:

- Define machine learning and understand the basic theory underlying machine learning.
- Differentiate supervised, unsupervised and reinforcement learning.
- To present the fundamental principles and practices of AI and ML to address the real-world mechanical engineering problems.
- The course is designed to develop a basic understanding of problem solving, knowledge representation, reasoning and learning methods of AI
- Design and implement a typical AI problem to be solved Using Machine Learning Techniques

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Hand-on experience on Python Programming	L2
CO2	Demonstrate the representation of knowledge and reasoning	L2
CO3	Comprehend the ideas of AI and problem-solving techniques	L3
CO4	Realize Machine Learning techniques in supervised and unsupervised learning	L3
CO5	Recognize the importance of data science, AI & ML in Mechanical Engineering	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Introduction, Basics: Basic types, variables, Decision making and Loops, Strings, Data Structures: Lists, Tuples, Sets, and Dictionaries Regular Expression Operations, Modules. Object oriented programming in python: Classes, Constructors, and Object Methods.	
MODULE 2	10Hrs
NumPy - Overview, NumPy Array creation and basic operations, NumPy Universal	

functions, Selecting and retrieving Data, Data Slicing. Pandas - Overview, Object Creation: Series Object, Data Frame Object, View Data, selecting data by Label and Position, Data Slicing, Setting Data, applying functions to data, Analysing Data for missing values. Matplotlib - Overview, creating basic chart: Line Chart, Bar Charts and Pie Charts, Plotting from Pandas object, Saving a plot.	
MODULE 3	08Hrs
Neural Network basics: History behind neural networks, Relationship between biological neuron and artificial neuron, Perceptron and working mechanism, Architecture of artificial neural network, Types of activation functions.	
MODULE 4	08Hrs
Introduction to Supervised learning, Linear Regression Logistic Regression, Naive Bayes, Decision Tree, KNN, Random Forest, Support Vector Machine Introduction to Unsupervised learning, PCA, clustering approaches: K-means, Hierarchical clustering Natural Language Processing: Language models, n-grams, Vector space models, Bag of words.	
MODULE 5	08Hrs
Machine learning application using python for mechanical engineering datasets: mechanical vibrations - heat transfer - fluid mechanics – manufacturing process. Smart Manufacturing, Smart Transportation and Autonomous Vehicles. Robotics, Quality control.	

TEXT BOOKS:

1. Nagy Z. Artificial Intelligence and Machine Learning Fundamentals: Develop real-world applications powered by the latest AI advances. Packt Publishing Ltd; 2018.
2. Sebastian Raschka and Vahid Mir Jalili, Python Machine Learning, Second Edition: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow Paperback – September 20, 2017

REFERENCES:

1. David L. Poole, Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
2. Nils J. Nilsson, the Quest for Artificial Intelligence, Cambridge University Press, 2009

SEMESTER	V

YEAR	III					
COURSE CODE	20ME3508					
TITLE OF THE COURSE	ADDITIVE MANUFACTURING					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- Understand the importance of additive manufacturing in advance manufacturing process.
- Explore the potential of additive manufacturing in different industrial sectors
- Acquire knowledge, techniques and skills to select relevant additive manufacturing process.
- Apply 3D printing technology for additive manufacturing
- Exploit the technology used in additive manufacturing

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand the working principles and process parameters of additive manufacturing processes	L2
C02	Explore different additive manufacturing processes and suggest suitable methods for building a particular component	L1
C03	Perform suitable Pre & post processing operation based on product repair requirement	L4
C04	Design and develop a working model using additive manufacturing Processes	L6
C05	Able to identify, analyze and solve problems related to Additive Manufacturing	L3

COURSE CONTENT:

MODULE 1: INTRODUCTION TO ADDITIVE MANUFACTURING

06Hrs

Introduction to AM, AM evolution, Historical development, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM.

MODULE 2: ADDITIVE MANUFACTURING PROCESSES

09Hrs

Types, Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping

(LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).	
MODULE 3: ADDITIVE MANUFACTURING MACHINES AND SYSTEMS	09Hrs
Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors. Introduction to NC/CNC/DNC machine tools, CNC programming and introduction, Hardware Interpolators, Software Interpolators, Recent developments of CNC systems for additive manufacturing.	
MODULE 4: PRE-PROCESSING IN ADDITIVE MANUFACTURING	09Hrs
Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.	
MODULE 5: POST-PROCESSING IN ADDITIVE MANUFACTURING	09Hrs
Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing, Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.	

TEXT BOOKS:

1. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
2. Gibson, I, Rosen, D W., and Stucker, B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010

REFERENCES:

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007
2. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
3. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3509					
TITLE OF THE COURSE	AUTOMATED MANUFACTURING SYSTEMS					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- To provide a comprehensive introduction to industrial automation
- To provide comprehensive introduction of various automation systems and related techniques for programming and system analysis.
- To introduce the modelling methods for the performance analysis and design of automation systems

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Appreciate the relevance of industrial automation.	L2
C02	Analyze the performance of automated production lines and automated assembly systems.	L3
C03	Design and draw the functional and logic circuits for the programming of the control elements for automation.	L3
C04	Understand the role of computer-numerical control and robotics in programmable automation and estimate the effectiveness of programmable automation using cycle time analysis	L4
C05	Become familiar with the tools and techniques for automated inspection.	L2

COURSE CONTENT:

MODULE 1: INTRODUCTION

08Hrs

Automation in production systems. Fixed, flexible and programmable automation.

Principles, reasons and strategies for automation.

Automated systems – elements, functions, levels of automation. Continuous Vs discrete

Control. Product/production relationships, Production concepts and mathematical models, Costs of manufacturing operations.

MODULE 2: AUTOMATED PRODUCTION LINES AND AUTOMATED

08Hrs

ASSEMBLY	
Fundamentals of automated production lines. Applications. Analysis of transfer lines with no internal storage. Analysis of storage lines with storage buffers. Fundamentals of automated assembly systems. Design for automated assembly.	
MODULE 3: CONTROL ELEMENTS FOR AUTOMATION	09Hrs
Sensors, Sensors position and velocity feedback. Actuators. Servo control. ADC, DAC. Control of electro-hydraulic and electro-pneumatic systems – Fluid-power symbols and Fluid-power control circuits. Programmable logic controllers – architecture - Ladder logic diagrams.	
	09Hrs
MODULE 4: PROGRAMMABLE AUTOMATION	
NC and CNC units – Part programming – Direct Numerical control – Adaptive control. Robot anatomy – specifications – ends effectors – applications in manufacturing. Robot cell design and control. Robot cycle-time analysis. Flexible manufacturing systems.	
MODULE 5: AUTOMATED MATERIAL HANDLING AND INSPECTION	08Hrs
Automated guided vehicle systems. Automated storage and retrieval systems, carousel storage, and their analysis. Automated inspection systems: Inspection metrology and conventional methods. Coordinate measuring machine. Surface measurement. Introduction to Machine Vision and other optical methods. Non-contact and non-optical inspection techniques.	

TEXT BOOKS:

1. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 4th Edition, Pearson, 2016..

REFERENCES:

1. B. Benhabib, Manufacturing: Design, Production, Automation and Integration, New York: Marcel Dekker, 2003.
2. Y. Altintas, Manufacturing Automation, Cambridge University Press, 2nd Edition, 2012.
3. J.A. Rehg, Introduction to Robotics in CIM Systems, 5th edition, Prentice Hall, 2003.

SEMESTER	V
YEAR	III
COURSE CODE	20ME3510

TITLE OF THE COURSE	INTRODUCTION TO HYBRID & ELECTRIC VEHICLES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Project s Hours	Total Hours	Credits
	3		-	-	42	3

COURSE OBJECTIVES :

The objectives of the Course are to

- Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
- Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
- Analyze various electric drives suitable for hybrid electric vehicles. Discuss different energy storage technologies used for hybrid electric vehicles and their control.
- Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.	L3
CO2	Analyze the use of different power electronics devices and electrical machines in hybrid electric vehicles.	L3
CO3	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	L3
CO4	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.	L3
CO5	Design and develop the electric propulsion unit and its control for hybrid electric vehicles.	L3

COURSE CONTENT:

MODULE 1	8Hrs

Introduction: State of the Art of HEVs, Challenges and Key Technology of HEVs. Hybridization of the Automobile: Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs). HEV Fundamentals: Introduction, Vehicle Model, Vehicle performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics.	
MODULE 2	8Hrs
Plug-in Hybrid Electric Vehicles: Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, Component Sizing of EREVs, Component Sizing of Blended PHEVs, Vehicle-to-Grid Technology. Power Electronics in HEVs: Power electronics including switching, AC-DC, DC-AC conversion, electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics.	
MODULE 3	10Hrs
Electric Machines and Drives in HEVs: Introduction, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors.	
MODULE 4	8Hrs
Batteries, Ultracapacitor, Fuel Cells, and Controls: Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.	
MODULE 5	8Hrs
Integration of Subsystems: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems. Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.	

TEXT BOOKS :

- 1 Husain, I. (2010). Electric and hybrid vehicles: design fundamentals. CRC press.
- 2 Eshani, M., Gao, Y., Gay, S. E., & Emadi, A. (2005). Modern electric, hybrid electric and fuel cell vehicles. Fundamentals, Theory, and Design. Boca

Raton, FL: CRC.

REFERENCES :

1. Laraminie, J., & Lowry, J. (2003). Electric vehicle technology explained.
2. Chris, M., Masrur, M. A., & Gao, D. W. (2011). Hybrid electric vehicles: principles and applications with practical perspectives. Masrur, David Wenzhong Gap.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3511					
TITLE OF THE COURSE	AUTOTRONICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	3		-	-	42	3

COURSE OBJECTIVES :

The objectives of the Course are to

- Learn the basics of electrical and Laws.
- Study about the electrical safety and importance of the earthing.
- Study the construction and principle of DC motor and its types.
- Understand about the generator, alternator, regulator and starting motor and mechanism.
- Study about the different ignition system.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Recognize and understand different wiring diagrams used in manufacturer's workshop manuals.	L3
CO2	Identify the various modules and sensors from the wiring diagrams.	L3
CO3	determine the function and operation of various electronic components	L3
CO4	Understand their role in the management of the vehicle control	L3

C05	Understand construction and working of different electric and hybrid vehicles.	L3

COURSE CONTENT:	
MODULE 1	8Hrs
INTRODUCTION : AUTOMOTIVE ELECTRICAL SYSTEMS : Automotive electric power generation, Storage & Distribution systems, Wiring harness, Circuit diagrams and symbols, 12/24/42 volt system, Positive earth and negative earth, Earth return and insulated return systems, Multiplexed wiring systems, Electromagnetic compatibility, Electromagnetic interference, Controlled Area Networks (CAN) Battery: Types, Principle of lead acid battery, Constructional details, Recharging the battery, Battery ratings, Battery Performance, Battery capacities, Battery efficiency, Battery tests, Battery failures, Alkaline battery, Maintenance free batteries, Hybrid batteries	
MODULE 2	8Hrs
CHARGING SYSTEMS & REGULATORS : Generators, A. C. Generators, Magneto Constant current & Voltage systems, Current & Voltage regulator, Semi-conductor type regulator, Regulator for alternators Starting Systems: Requirements of Starting system, Starting system layout, Selection of motor, matching battery, Drive mechanisms, Permanent magnet motors	
MODULE 3	10Hrs
IGNITION SYSTEMS: Introduction, Types, Ignition coil, Distributor, Cam angle & Contact angle gap, Advance mechanisms, Ballast Resistance, Limitations of coil Ignition, Transistorized Ignition systems, Spark plugs, types, Construction. LIGHTING SYSTEMS: Fundamentals, Headlight, Types, Lighting circuits, Interior lighting, Signaling, LED lighting, Gas discharge lighting	
MODULE 4	8Hrs
AUTOMOTIVE EQUIPMENT & ACCESSORIES: Fuel gauge, Oil pressure gauge, Temperature gauges, Speedometer, Warning Lights, Electric Horn, Horn Relay, Wind Shield wipers, Heaters & Defrosters, Electric windows. AUTOMOTIVE SENSORS & ACTUATORS: Actuators, Air-flow rate sensor, Angular position sensor, Throttle angle sensor, Temperature sensor, Knock sensor, Pressure sensor. Feedback for engine control, Solenoid actuators, Motorized actuators.	
MODULE 5	8Hrs

AUTOMOTIVE ELECTRONIC SYSTEMS: Electronic Ignition systems, Electronic injection systems, Antilock brake system circuit, Traction control, Electronic control of automobile transmission, Active suspension, Engine management system.

ELECTRONIC AND HYBRID VEHICLES : Types, Energy sources – batteries, Fuel cells, Solar and Hydrogen, Electric machines and controllers, Design considerations, Challenges and recent developments.

TEXT BOOKS :

- 1 Kohli, P. L. (1983). Automotive electrical equipment. Tata McGraw-Hill Publishing Company.
- 2 Denton, T. (2017). Automobile electrical and electronic systems. Routledge.

REFERENCES :

1. Ribbens (2013.), "Understanding Automotive Electronics", 7th Edition, Elsevier, Indian Reprint,
2. Tom Denton (2000), "Automobile Electrical and Electronics Systems", Edward Arnold Publishers.
3. Barry Hollembeak (2001), "Automotive Electricity, Electronics & Computer Controls", Delmar Publishers.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3512					
TITLE OF THE COURSE	REFRIGERATION AND AIR CONDITIONING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- Study the methods of refrigeration, Carnot cycle, Unit of refrigeration and coefficient of performance
- Discuss classification and properties of refrigerants
- Describe the Vapour compression and Vapour absorption systems
- Understand psychrometric properties and processes

- Study Air conditioning systems and air conditioning loads
- Understand the measuring instruments and sensors used in air conditioning

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain different methods of refrigeration	L2
CO2	Select the suitable refrigerant based on application and environmental consideration	L3
CO3	Analyse Vapour compression and Vapour absorption refrigeration systems	L4
CO4	Apply the knowledge of psychrometric properties and processes for air conditioning	L3
CO5	Compute air conditioning loads and Interpret air conditioning methods	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Methods of refrigeration, ice refrigeration, evaporative refrigeration, air refrigeration, vapour refrigeration, dry ice refrigeration, pulse tube refrigeration, thermo-acoustic refrigeration, reverse Carnot cycle, block diagram of refrigerator & modified reverse Carnot cycle (Bell Coleman cycle). Unit of refrigeration and coefficient of performance.	
MODULE 2	08Hrs
Refrigerants: Classification of refrigerants, desirable properties of refrigerants, environmental issues, Ozone depletion potential and global warming potential & life cycle climate performance. Selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes.	
MODULE 3	10Hrs
Vapour Compression Systems: Vapor compression cycle: p-h and T-s diagrams – deviations from theoretical cycle – sub cooling and super heating-effects of condenser and evaporator pressure on COP- multi pressure system – low temperature refrigeration – cascade systems – problems. Vapour Absorption Systems: Introduction, working of simple vapour absorption system, desirable properties of binary mixture (aqua-ammonia), Lithium-Bromide (Li- Br) absorption system, performance evaluation, applications and comparison between vapour compression system and vapour absorption system.	
MODULE 4	08Hrs

Properties of moist air-Gibbs Dalton law, specific humidity, dew point temperature, degree of saturation, relative humidity, enthalpy, humid specific heat, wet bulb temperature thermodynamic wet bulb temperature, psychrometric chart; psychrometric processes.	
MODULE 5	08Hrs
Air conditioning: Introduction, Classification, ASHRAE Nomenclature, Applications, Different Air-Conditioning Systems: Central, Unitary, Window, Packaged & Transport Air conditioning loads: Outside and inside design conditions; Sources of heat loads and calculations; Air filters; air conditioning systems with controls: temperature, pressure and humidity sensors, actuators & safety controls.	

TEXT BOOKS :

1. Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill, 2008.
2. Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 1983.

REFERENCES :

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000
2. Domkundwar, V.M (2014), Refrigeration and Air-Conditioning Data Book, Dhapapatraihill, 1998.

SEMESTER	V					
YEAR	III					
COURSE CODE	20ME3513					
TITLE OF THE COURSE	TOOL DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
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COURSE OBJECTIVES :

- To understand the various types of tooling materials and their industrial applications.
- To develop capability to design and select single point and multipoint cutting tools for various machining operations.
- Exposure to variety of locating and clamping methods available.
- To enable the students to design jigs and fixtures for simple components
- To expose the students to the design/selection procedure of sheet metal and injection mold

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Select appropriate cutting tools required for producing a component.	L2
CO2	Apply design concepts of single point and multi-point cutting tools	L3
CO3	Demonstrate knowledge of various press tools and sheet tool operations.	L2
CO4	Classify and explain various types of injection moulding dies.	L4
CO5	Analyze and design a jig/fixture for a given simple component	L4

COURSE CONTENT:	
MODULE 1	08Hrs

Different tooling materials: cemented carbides, coated carbides, cermet's, ceramics and polycrystalline tool materials. Selection and properties of tool materials, plastics as tool materials, Tooling materials – properties and applications of ferrous, non-ferrous and non-metallic materials. Case studies.	
MODULE 2	08Hrs
Design of single point cutting tools - various systems of specifications, geometry and their interrelation, theories of formation of chip and their effect. Design of multipoint cutting tools – Design elements, nomenclature and geometry of drill bit, milling cutter, reamer and broaching tool. Cutting parameters and machining time calculation for drilling, milling, reaming and broaching operation. Case studies	
MODULE 3	10Hrs
Working of a power press and classification of presses. Press working terminology, Types of dies-Simple, progressive, compound and combination dies. Components of a simple die, press tool operation, die accessories, press tool operations. Shearing theory, cutting clearance between punch and die, methods of reducing cutting forces, Centre of pressure and problems, scrap strip layout. Design problems on blanking and piercing dies for simple components. Case studies	
MODULE 4	08Hrs
Injection moulding machine and its elements, general configuration of a two plate mould. Introduction to gate, runner, parting surface, ejection system. Core and cooling system. Design problems on injection mold. Case studies	
MODULE 5	08Hrs
Functions and differences between jigs and fixtures, advantages in mass production, design principles, economics of jigs and fixtures. Location: 3-2-1 Principle of location, different types of locating elements. Clamping: Principles of clamping, types of clamping devices. Drill jigs: Different types, Types of fixtures: Turning fixtures, milling fixtures, grinding fixtures, fixturing for CNC machining centres, and modular fixtures. Case studies.	

TEXT BOOKS :

1. Donaldson. C, Lecain.G.H and Goold.V.C, Tool Design, Tata McGraw Hill publishing company limited, New Delhi, 2002.

REFERENCES :

1. Surendra Kenav and Umesh Chandra, Production Engineering Design (Tool Design), New Delhi, 1994.
2. Mehtha.N.K, Machine Tool Design and Numerical Control, Tata Mc-Graw Hill, Third Edition, 2012.

VI SEM - MECHANICAL ENGINEERING

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3601					
TITLE OF THE COURSE	Design of Machine Elements - II					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	IV	20ME2402	Mechanics of Materials

COURSE OBJECTIVES :

- To understand use of different types of springs and determine safe design of spring under static and fluctuating loading conditions.
- To understand the standard nomenclature, forces, failures, application, design procedure of Spur and Helical gears (As per AGMA)
- To understand the standard nomenclature, forces, failures, application, design procedure of Bevel and Worm gears (As per AGMA) and to determine standard geometry under given loading condition
- To understand the design procedure, failures and application of Ball Bearings and Sliding contact bearing
- Design clutches and brakes required for power transmission.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Classify different kinds of springs, gears, bearings,clutches and brakes.	L2
C02	Compute tooth strength for spur, helical, bevel and worm gears	L3
C03	Interpret the pressure distribution in a journal bearing.	L3
C04	Analyze the design of hydrodynamic journal bearing.	L4
C05	Select suitable clutch plate and break shoe for a given applications.	L2

COURSE CONTENT:	
MODULE 1	08Hrs
Springs: Types, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, springs under fluctuating loads. Leaf springs: Stresses in leaf springs. Equalized stresses, energy stored in springs, torsion, Belleville and rubber springs.	
MODULE 2	10Hrs
Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear load. Helical Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads.	
MODULE 3	08Hrs
Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic and wear loads. Worm Gears: Definitions, design based on strength, dynamic, wear loads and efficiency of worm gear drives.	
MODULE 4	08Hrs
Bearings: Lubricants and their properties, mechanisms of lubrication bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, Heat dissipated, bearing materials, examples of journal bearing and thrust bearing design.	
MODULE 5	08Hrs
Clutches & Brakes: Design of clutches: Single plate, multi plate and cone clutches. Design of Brakes: Block and band brakes: Self-locking of brakes: Heat generation in brakes.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Determination of pressure distribution in journal bearing
2.	Modelling and stress analysis of Spur and Helical Gear tooth by using CAD/CAE software
3.	Modelling and stress analysis of helical and leaf springs using CAD/CAE software
4.	Modelling and stress analysis of brake by using CAD/CAE software
5.	Modelling and stress analysis of single plate and multi-plate clutches by using CAD/CAE software
6.	Open ended project using FEA software

TEXT BOOKS :

1. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill, 6th Edition, 2009.
2. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition, 2007.

REFERENCES :

1. Robert L. Norton, Machine Design, Pearson Education Asia, fifth edition, 2014.
2. Machine Design, Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., Special Indian Edition, 2008.

3. K. Lingaiah, Design Data Hand Book, McGraw Hill, 2nd Edition, 2003.
4. K. Mahadevan and K. Balaveera Reddy, Data Hand Book, CBS Publication, Fourth edition, 2013.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3602					
TITLE OF THE COURSE	Finite Element Methods					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	1	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1.			

COURSE OBJECTIVES :

- To help students to differentiate between finite difference and finite volume methods
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range two-dimensional real world structural and thermal problems
- To help students understand the use of higher order finite elements

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Differentiate between finite difference and finite volume methods and their applications.	L3
CO2	Analyze a wide range two-dimensional field problems using finite element techniques	L2
CO3	Apply FE techniques to situations involving heat transfer by conduction	L3
CO4	Apply FE techniques in structural and solid mechanics	L3
CO5	Appreciate the use of higher order elements in FEM and apply the same	L3

COURSE CONTENT:	
MODULE 1	
	10Hrs

Introduction to computational methods, Finite difference method, Finite volume methods, Direct stiffness method, Integral formulation for numerical Solution – Variational method, Method of weighted residuals, Potential energy formulations; Principle of virtual work, Division of the region into elements - One dimensional linear element, Linear triangular element, Bilinear rectangular element, Representation for scalar and vector fields, Global, local and natural coordinate systems in one, two and three dimensions.	
MODULE 2	08Hrs
Governing differential equations; Integral equations for the element matrices, Triangular element matrix, Torsion of noncircular sections, General theory – Twisting of a square bar, Shear stress components, Evaluation of the twisting torque, Flow of an Ideal Fluid – Potential Formulation, Groundwater Flow, Flow Around a Cylinder, Other field problems, Derivative boundary conditions – 1D, Derivative boundary conditions – 2D,	
MODULE 3	08Hrs
Heat transfer by conduction, The one dimensional fin – 1, The one dimensional fin – 2, The composite walls, The two-dimensional fin, Boundary conditions, Long two-dimensional bodies – 1, Long two-dimensional bodies – 2, Axi-symmetric field problems, The differential equation – Axi-symmetric elements, Galerkin's method, Element matrices,	
MODULE 4	08Hrs
The axial force member - Element matrices, The truss element – Element matrices, Analysis of a pinned truss – 1, Analysis of a pinned truss – 2, A Beam element, Shape functions, Element matrices, Analysis of a statically indeterminate beam – 1, Analysis of a statically indeterminate beam – 2, A plane frame element – Element matrices, Two dimensional stress analysis - Stress, strain and Hooke's Law, The strain displacement equations, Two dimensional elasticity - Plane stress and plane strain, The displacement equations, The element matrices, Element stresses, Axi-symmetric stress analysis - Element matrices, Surface loads,	
MODULE 5	08Hrs
Iso-parametric elements in one and two dimensions, use of higher order elements, Element matrices, Introduction to Transient domain & Dynamic analysis, Changing the variables of integration- One-dimensional integrals, Two-dimensional integrals, Numerical Integration techniques- one-dimensional integrals, Quadrilateral regions, Triangular regions; Evaluating [B]; Evaluating the surface integrals, Pre and post processing, capability of commercially available FEM packages, Error analysis	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28	
1.	Bars of constant cross section area, tapered cross section area and stepped bar

2.	Trusses (Minimum 2 exercises) Beams – Simply supported, cantilever, beams with UDL, beams with varying load etc; (Minimum 6 exercises)
3.	Dynamic analysis 1) Fixed – fixed beam for natural frequency determination 2) Bar subjected to forcing function 3) Fixed – fixed beam subjected to forcing function
	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises)
4.	Stress analysis of a rectangular plate with a circular hole

TEXT BOOKS :

1. “Applied Finite Element Analysis”, L.J.Segerlind, John Wiley and Sons
2. “Applied Finite Element Analysis”, G.Ramamurthy, I.K.International Publishing House ,2009

REFERENCES :

1. “Concepts and Applications of Finite Element Analysis”, Cook, R. D., Malkus, D. S., Plesha, M. E., and Witt, R. J. Wiley Student Edition, Fourth Edition, First Reprint 2007.
2. “The Finite Element Method in Engineering”, Rao, S. S., Butterworth-Heinemann (An imprint of Elsevier), Published by Elsevier India Pvt. Ltd., 2007.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3603					
TITLE OF THE COURSE	Mechanical Vibrations					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	70	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

- To learn analytical, experimental, and numerical analysis of vibrational phenomena.
- To learn the mathematical modelling of mechanical systems
- To understand the application of the law of conservation of energy in solving problems through energy methods.
- To understand the importance of damping in mechanical systems
- To design the vibration absorbers and isolators
- To acquaint with the principles of vibration measuring instruments

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Construct mathematical models to represent dynamic systems	L3
CO2	Analyse vibratory responses of single, two and multi degree of freedom mechanical systems	L4
CO3	Demonstrate the knowledge of vibration measuring instruments	L3
CO4	Apply AI techniques to Vibration Analysis of mechanical systems	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction, classification of vibration systems, harmonic motion, natural frequency & response, effects of vibration, superposition of simple harmonic motions, Single degree freedom system- equation of motion, Free vibration, equivalent systems, torsional vibrations, vibrations of systems with viscous damping, Logarithmic decrement, energy dissipation in viscous damping.	
MODULE 2	08Hrs
Forced vibration, harmonic excitation with viscous damping, steady state vibrations, forced vibrations with rotating and reciprocating unbalance, support excitation, vibration isolation, transmissibility, displacement, velocity and acceleration measuring instruments.	
MODULE 3	08Hrs
Introduction, principal modes, torsional system with damping, coupled system, principle of vibration absorber, undamped dynamic vibration absorbers, torsional vibration absorber, centrifugal pendulum absorbers, vibration isolators and dampers.	
MODULE 4	08Hrs
Numerical Analysis- Influence coefficients, reciprocal theorem, torsional vibration of multi-degree rotor system, Rayleigh's method, Dunkerely's, Holzer's and Stodola methods, Rayleigh-Ritz method, critical speed of shafts, whirling of uniform shaft, shaft with one disc with and without damping, multi-disc shafts, secondary critical speed.	
MODULE 5	08Hrs
Vibration instruments – transducer, vibrometer, accelerometer, seismometer, vibration pickup, proximity probe spectrum analyzer, principle of seismic instruments, frequency measuring instruments, diagnostic tools, Introduction to condition monitoring and fault diagnosis using Artificial Intelligence approach.	

List of Laboratory/Practical Experiments activities to be conducted (if any) :28Hrs	
1.	Plotting and analysis of various graphs of free and forced vibrations using MATLAB.
2.	Virtual lab exercises provided by MHRD
3.	Free and forced vibration
4.	Whirling of the shaft and finding the critical speed of the shaft.
5.	Students will be trained in MATLAB and ANSYS for solving simple vibration problems and using AI & ML techniques in condition monitoring.

TEXT BOOKS :

1. Rao.S.S, Mechanical Vibrations, 6thEdition, Pearson Education Inc. Delhi 2018.
2. Thomson.W.T, Theory of Vibration and its Applications, 5thEdition, Prentice Hall, New Delhi, 2001.

REFERENCES :

1. Rao.J.S and Gupta.K, Introductory Course on Theory and Practice of Mechanical Vibrations, New Age International, New Delhi, 1999.
2. Ramamurthi.V, Mechanical Vibration Practice with Basic Theory, 1st Edition, Narosa Publishing House, Chennai, 2000.
3. Keith Mobley.R, Vibration Fundamentals, Plant Engineering Maintenance Series, Elsevier, 2007.
4. S.Graham Kelly, Mechanical Vibrations - Schaum's outline series, McGraw Hill, 2007

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ENC002					
TITLE OF THE COURSE	LAW FOR ENGINEERS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	2	-	-	-	28	2

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	--	--	--

Course Objectives:

The students will be able to

1. Apply the knowledge of the constitutional literacy to become aware of the

- fundamental rights and duties in their role as Engineers
2. Understanding of ethical and legal aspects of advertising, consumer problems and their redressal mechanism related to product and service standards.
 3. Demonstrate an advanced and integrated understanding of the nature and extent of the corporate entity principle and to understand how this principle applies to corporate groups
 4. Critically evaluate the extent and application of the Corporate Law.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand process of ethical and moral analysis in decision making scenarios and inculcate ethical behavior as a trait for professional development.	L1
CO2	Apply the knowledge to solve practical problems with regard to personal issues & business enterprises.	L3
CO3	Identify the conflict management in legal perspective and judicial systems pertaining to professional environment; strengthen the ability to contribute to the resolution of human rights & Ragging issues and problems through investigative and analytical skills.	L2

COURSE CONTENT:

Module I: Introduction		08 Hrs
Introduction to Indian legal system, Review of Constitution of India, Sources of Law and Judicial system. Contracts and its Elements: Employment contracts, Contract Interpretation, service contract , Contract of Indemnity, Law of Agency, Employment Agreement		
Module II : Legal documentation		08 Hrs
Legal documentation: Drafting of legal documents including Non-Disclosure Agreements (NDA) , Request for proposal (RFP), Collaboration Agreement , Joint Venture Agreements, Tendering and sub-contracting		
Module III: Property Rules, Trademarks & Copy Rights		10 Hrs
Intellectual Property Rules (IPR) Overview, Trademarks , Copy Rights , Patents with special emphasis in Biotechnology Inventions, Software Circuits and Design, Protection in Foreign Countries		
Module IV: Introduction to Labour and Environmental Laws		08 Hrs
Labour Laws: Provident Fund, ESIC, Gratuity, Bonus, Perquisites, Contract labour, Health, Safety and welfare of construction workers, Introduction to Environmental Law, Concept of Law & Policy , Environment and Governance ,Sustainable Development and Environment , Understanding Climate Change and its processes – CDP, CDMs and Carbon Off Setting, Overview of International		

Environmental Laws, Introduction to Environment and IPR	
Module V: Cyber Laws & Taxation	
Cyber Laws , E-Commerce and E-Governance, Taxation: Income Tax, Service Tax, VAT, Excise Duty, RTI Act.	
	10 Hrs

Text books:

1. V.S. Datey, Indirect Taxes: Law and Practice, Taxmann Publications (P) Ltd, Latest Edition Publications (P) Ltd, latest Edition.
2. S.C. Srivastava, Industrial Relations and Labour Laws, Vikas Publishing House Pvt.Ltd.
3. Joseph Minatiur, Indian Legal System, Indian Law Institute, New Delhi.

Reference books:

1. Kamith Seth, Computer Internet and New Technology Laws, LexisNexis, First Edition 2013.
2. Prafulla C Pant, The Arbitration and Conciliations Act, 1996, ButterworthsIndia, New Delhi..
3. J. Beatson, Anson's Law of Contract, Oxford University Press.

PROGRAM ELECTIVE – II

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3604					
TITLE OF THE COURSE	DRIVES & CONTROL SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3		-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- To help students to differentiate between Servos and controls.
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range servo and control problems.
- To help students understand the use of different drives and power rating.
- To help students to differentiate between Servos and controls.
- To enable students with the necessary mathematical and theoretical tools and skills required to analyze a wide range servo and control problems.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.	L2
C02	Discuss the concept of transfer functions for the representation of differential equations	L3
C03	Discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.	L3
C04	Represent servo drive components by their transfer function, to combine the servo drive building blocks into system block diagrams.	L3
C05	Determine the frequency response techniques for proper servo compensation.	L3

COURSE CONTENT:

COURSE CONTENT:	
MODULE 1	8Hrs
ELECTRICAL DRIVES Electrical Drives: Electrical Drives, Advantages of Electrical Drives. Parts of Electrical Drives, Choice of Electrical Drives, Status of dc and ac Drives. Dynamics of Electrical Drives: Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation. Equivalent Values of Drive Parameters, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations, SteadyState Stability, Load Equalization. Control Electrical Drives: Modes of Operation, Speed Control and Drive Classifications, Closed loop Control of Drives.	
MODULE 2	8Hrs
SELECTION OF MOTOR POWER RATINGS Selection of Motor Power Ratings: Thermal Model of Motor for Heating and Cooling, Classes of Motor Duty, Determination of Motor Rating. Direct Current Motor Drives: Controlled Rectifier Fed dc Drives, Single Phase Fully Controlled Rectifier Control of dc Separately Excited Motor, Single Phase Half Controlled Rectifier Control of dc Separately Excited Motor, Three Phase Fully Controlled Rectifier Control of dc Separately Excited Motor, Three Phase Half Controlled Rectifier Control of dc Separately Excited Motor, Multi quadrant Operation of dc Separately Excited Motor Fed Form Fully Controlled Rectifier, Rectifier Control of dc Series Motor, Supply Harmonics, Power Factor and Ripple in Motor Current, Chopper Control of Separately Excited dc Motor, Chopper Control of Series Motor.	

MODULE 3	10Hrs
INDUCTION MOTOR DRIVES Analysis and Performance of Three Phase Induction Motors, Operation with Unbalanced Source Voltage and Single Phasing, Operation with Unbalanced Rotor Impedances, Analysis of Induction Motor Fed From Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources.	
MODULE 4	8Hrs
SYNCHRONOUS MOTOR DRIVES Voltage Source Inverter (VSI) Control, Cyclo-converter Control, Closed Loop Speed Control and Converter Rating for VSI and Cyclo-converter Induction Motor Drives, Variable Frequency Control from a Current Source, Current Source (CSI) Control, current regulated voltage source inverter control, speed control of single phase induction motors.	
MODULE 5	8Hrs
PERFORMANCE CRITERIA Percent Regulation, Servo System Responses. Servo Plant Compensation Techniques: Dead-Zone Nonlinearity, Change-in-Gain Non-linearity, Structural Resonances, Frequency Selective Feedback, Feedforward Control. Machine Considerations: Machine feed drive Considerations, Ball Screw Mechanical Resonances and Reflected Inertias for Machine Drives.	

TEXT BOOKS :

- 1 "Industrial Servo Control Systems Fundamentals and Applications", George W. Yountkin, 1st Edition, 2003.
- 2 Fundamentals of electrical drives by G K DUBEY, Narosa publications, 2005

REFERENCES :

- 1 "Servo Motors and Industrial Control Theory", Riazollah Firoozian, R. Springer, 2nd Edition, 2014.
- 2 "DC SERVOS Application and Design with MATLAB", Stephen M. Tobin, CRC, 1st Edition, 2011.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3605					
TITLE OF THE COURSE	ELECTRICAL MACHINES AND POWER SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	3	-	-	-	48	3

Pre-requisite Courses (if any)			
#	Sem/Yea r	Course Code	Title of the Course

COURSE OBJECTIVES:

The course will enable the students to:

1. To make the students understand the working principle of transducers and sensors.
2. To understand various types of lighting system and charging system..
3. To understand various types of sensors used in engine and application of each sensor.
4. To have a broad knowledge about electrical and electronic components in the vehicle

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	To explain various electronic systems present in the vehicle.	L1
C02	To do demonstrate on quantity of energy conversion through calculations for actual processes	L2
C03	The student will know about the Automatic Transmission and Applications of Automatic Transmission	L1
C04	To explore current trend automotive electronic engine management.	L2
C05	The student will understand the principle and working of the clutch, gearbox	L1

COURSE CONTENT:	
MODULE 1: BATTERIES AND ACCESSORIES	08hrs
Principle and construction of lead acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on batteries, maintenance and charging	
MODULE 2: STARTING SYSTEM	08hrs
Condition at starting, behaviour of starter during starting, series motor and its characteristics, principle and construction of starter motor, working of different starter drive units, care and maintenances of starter motor, starter switches.	
MODULE 3: CHARGING SYSTEM AND LIGHTING	10 hrs
Generation of direct current, shunt generator characteristics, armature reaction, third brush regulation, cut-out. Voltage and current regulators, compensated voltage regulator, alternators principle and constructional aspects and bridge rectifiers, new developments.	
Lighting system: insulated and earth return system, details of head light and side light, LED lighting system, head light dazzling and preventive methods – Horn, and wiper system, advances in lighting system (adaptive front lighting system – AFLS).	
MODULE 4 FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS	08 hrs
Current trends in automotive electronic engine management system, electromagnetic interference suppression, electromagnetic compatibility, electronic dashboard instruments, on board diagnostic system, security and warning system.	
MODULE 5 SENSORS AND ACTUATORS	08 hrs
Types of sensors: sensor for speed, throttle position, exhaust oxygen level, manifold pressure, crankshaft position, coolant temperature, exhaust temperature, air mass flow for engine application. Solenoids, stepper motors, relay. Case study of any one of the automotive sensor-based application.	

TEXTBOOKS:

1. Allan Bonnick, "Automotive Computer Controlled Systems", 2011.
2. Tom Weather Jr and Cland C. Hunter, "Automotive Computers and Control System", Prentice Hall Inc., New Jersey.

REFERENCES:

- 1 Santini Al, "Automotive Electricity and Electronics", Cengage Learning, 2012
- 2 Tom Denton, "Automotive Electrical and Electronic System", SAEInternational, 2004.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3606					
TITLE OF THE COURSE	MATERIALS FOR ADDITIVE MANUFACTURING					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- Understand the importance of materials in additive manufacturing for various advanced process.
- Learn the concepts and the role of materials in material design and quality aspects
- Understand the various types of simulation and mathematical models and their practical use
- Utilize material handling equipment in manufacturing situations
- Have wide knowledge on usage of additive manufacturing in various applications

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Determine the appropriate materials for manufacturing process for the product to be made.	L1
C02	Analyze the suitability of a manufacturing process to convert the raw material to designed specifications.	L4
C03	Developing the material ability and expertise to apply the latest mathematical tools and techniques for computing and engineering practice.	L5
C04	Perform cost analysis for various manufacturing process to minimize the cost of processing the material.	L2
C05	Application of engineering and technological knowledge to solve a wide range of rapid manufacturing problems.	L3

COURSE CONTENT:	
MODULE 1: ROLE OF MATERIALS	09Hrs
Choosing Materials for Manufacturing, Multiple Materials, Metal AM Processes & Materials Composite Materials, Biomaterials, Hierarchical Materials & Bio mimetics, Ceramics & Bio-ceramics, Shape-Memory Materials, 4D Printing & Bio-active materials, Discussion on different materials used, multifunctional and graded materials in AM	
MODULE 2: MATERIAL DESIGN & QUALITY ASPECTS	09Hrs
Machines for Additive Manufacturing, Secondary Rapid Prototyping processes, Intellectual Property, Product Development, Commercialization, Trends and Future Directions in Additive Manufacturing. Design for AM (Build orientation, Topology optimization, Conformal cooling channels).	
MODULE 3: MATHEMATICAL MODELS IN AM	09Hrs
Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation. Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Model validation for different criteria). Thermal cycle, Single bead and multi bead formation in cladding based AM processes	
MODULE 4: ADDITIVE MANUFACTURING FOR BIO-MEDICAL DEVICES & OTHERS	09Hrs
Bio microfluidics, Tissue Engineering. 3D Printing in Medicine, Computer Aided Design approach, medical research and clinical grade AM materials and AM fabrication methods, Biomedical Applications, Direct Digital Manufacturing, Distributed Manufacturing, Mass Customization, , Aerospace & Automotive Applications, Architectural Engineering, Food & Consumer Applications, Personalized Surgery, Art, Fashion, Jewelry, Toys & Other Applications	
MODULE 5: RAPID MANUFACTURING OBJECTS	06Hrs
RM of polymeric objects, Direct and indirect routes for RM of metallic & ceramic objects, Advancement in RM (Synergistic integration of hybrid processes and multiple technologies). Smart materials.	

TEXT BOOKS:

1. Ian Gibson, David Rosen, and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer, New York, NY, 2015.
2. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014

REFERENCES:

4. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007
5. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018
6. Duc Pham, S.S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer-Verlag London, 2001.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3607					
TITLE OF THE COURSE	PROCESSING OF PLASTICS & COMPOSITES					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- Elaborate the fundamentals of plastics and polymer composites including their matrix & reinforcement material.
- understand the various processing techniques of plastic materials
- learn the basic knowledge on machining/joining of plastic materials
- Impart different processing techniques of polymer matrix composites.
- provide a wide knowledge on various secondary processing techniques of polymer composites

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand various kinds of plastics and polymer composite materials.	L2
C02	Distinguish various processing methods and its process parameters for different plastics	L2
C03	Interpret the machining/joining properties of different plastics	L3
C04	Demonstrate the various processing techniques of polymer composites along with their parameter and process control	L2
C05	Classify the different secondary processing techniques of polymer composites	L2

COURSE CONTENT:	
MODULE 1: INTRODUCTION TO PLASTICS AND COMPOSITES	08Hrs
Chemistry and Classification of Polymers – Properties of Thermoplastics – Properties of Thermosetting Plastics – Applications – Merits and Disadvantages. Fibres – Glass, Boron, Carbon, Organic, Ceramic and Metallic Fibers – Matrix Materials – Polymers, Metals and Ceramics	
MODULE 2: PROCESSING OF PLASTICS	09Hrs
Extrusion – Injection Moulding – Blow Moulding – Compression and Transfer Moulding – Casting – Thermo Forming. Process parameters, Applications & Limitations	
MODULE 3: MACHINING AND JOINING OF PLASTICS	08Hrs
General Machining properties of plastics – Machining Parameters and their effect – Joining of Plastics – Mechanical Fasteners – Thermal bonding – Press Fitting.	
MODULE 4: PROCESSING OF POLYMER MATRIX COMPOSITES	09Hrs
Open Mould Processes, Spray-layup, Bag Moulding, Compression Moulding with BMC and SMC –Filament winding – Pultrusion – Centrifugal Casting – Injection Moulding – Reaction injection molding, Autoclaving, Resin transfer molding-Application of PMC's.	
MODULE 5: SECONDARY PROCESSING OF POLYMER COMPOSITES	08Hrs
Secondary processing of polymer composites: Joining of polymer composites, Adhesive joining. Mechanical joining, Microwave joining, Induction and resistance welding, Drilling of polymer composites. Conventional vs ultrasonic drilling, Remedies for reducing drilling induce damages, Research tools for secondary processing.	

TEXT BOOKS:

1. A. Brent Strong (2005), Plastics: Materials and Processing, 3rd Edition, Pearson Publications.
2. Frank L. Matthews, R D Rawlings (1999), Composite Materials: Engineering and Science, CRC Press.

REFERENCES:

1. K. K. Chawla (2006), Composite Materials: Science and Engineering, Springer Publications.
2. Akira Kobayashi (1967), Machining of Plastics, 1st edition, McGraw-Hill Publications.
3. Michael L. Berins (1991), SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc., 1st Edition Springer Publications.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3608					
TITLE OF THE COURSE	AUTOMOTIVE CHASSIS & TRANSMISSION SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/ Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The course will enable the students to:

- To learn the types of chassis and axles.
- To study about the steering system and its methods.
- To understand the suspension systems and its components.
- To learn the functions of universal joint and propeller shafts.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To make students familiar with the constructional details of chassis and body.	L2
CO2	The student will understand the principle and working of the Torque Converters	L2
CO3	The student will know about the Automatic Transmission and Applications of Automatic Transmission	L1
CO4	The student will understand the principle and working of the Hydro-Static Drive and Electric Drives.	L2
CO5	The student will understand the principle and working of the clutch, gearbox	L2

COURSE CONTENT:

MODULE 1 Chassis & Body	08Hrs

Types of chassis layout with reference to power plant locations and drive. Vehicle frames. Various types of frames. Constructional details. Materials. Testing of vehicle frames., Loads acting on vehicle frame. Integrated body construction, BIW types and corresponding design parameters, Vehicle interior system, A, B, & C Pillar.	
MODULE 2 Front Axle And Steering System	08Hrs
Types of front axle. Constructions details. Materials. Front wheel geometry viz. Castor, Camber, King pin inclination, Toe-in. Conditions for true rolling motion of wheels during steering. Steering geometry. Ackerman and Davis steering system. Constructional details of steering linkages. Different types of steering gear boxes. Steering linkages and layouts. Power assisted steering.	
MODULE 3 Clutch and Gear Box	10Hrs
Clutch – function – clutch actuating mechanism – Mechanical and hydraulic types – clutch material – single plate dry clutch – dual plate dry clutch – multi plate wet clutch – semi centrifugal and centrifugal clutch – motor cycle clutch – Diaphragm clutch – fluid coupling and torque converter – Trouble shooting of Clutch. Gear Box – purpose – resistance offered to the motion of the vehicle – air resistance – rolling resistance – Resistance offered to the motion of the vehicle – gradient resistance – tractive effort -gear ratio – types of gear boxes – sliding mesh – constant mesh -synchromesh device – epicyclic – over drive – under drive and transfer cases – 4 wheel drive – gear shifting mechanism – floor shifting and steering column shifting – Automatic Gear box (CVT) -Trouble shooting of gear box.	
MODULE 4 Automatic Transmission systems	08Hrs
Principle of working of epi-cyclic gear train - Construction and working principle of Ford-T model gear box - Wilson gear box- construction, working and derivation of gear ratios - Cotal electromagnetic transmission - Automatic over-drive - Hydraulic control system for automatic transmission. Chevrolet automatic transmission - Turbo glide transmission - Power glide transmission - Toyota “ECT-i” [Automatic transmission with intelligent electronic control systems] - Mercedes Benz automatic transmission - Hydraulic clutch actuation system for automatic transmission	
MODULE 5 Hydro-Static Drive and Electric Drives	08Hrs
Hydrostatic drive – principle, types, advantages, limitations - Comparison of hydrostatic drive with hydrodynamic drive - Construction and working of typical Janny hydrostatic drive. Lay-out of elective drive - Principle of early and modified ward Leonard control systems – advantages, limitations, performance characteristics	

TEXTBOOKS:

1. Tim Gilles, Automotive Chassis-Brakes, Steering and Suspension, Thomson Delmer Learning, 2005.

2. Heldt.P.M, "Automotive Chassis", Chilton Co., New York, June 2012.

REFERENCES:

1. Jornsens Reimpell, Helmut Stoll, Automotive Chassis: Engineering Principles, Elsevier, 2nd edition, 2001.
2. Crouse.W.H, Automotive Chassis and Body, McGraw Hill New York, 1971.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3610					
TITLE OF THE COURSE	RENEWABLE ENERGY SOURCES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The course will enable the students to:

- To educate the students scientifically the new developments in renewable energy studies
- To make understand the new developments in non-conventional and renewable energy studies.
- To emphasize the significance of Green Energy Technologies

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To understand importance of solar energy applications	L1
CO2	To know the principles of power generation by wind energy	L2
CO3	To know ocean energy technologies to harness power	L2

C04	To appreciate the use of hydrogen as renewable energy source	L3
C05	Develop capability to do basic design of bio gas plant	L2

COURSE CONTENT:	
MODULE 1 Solar Energy	10 Hrs
Solar Energy- Solar radiation its measurements and prediction - solar thermal collectors - flat plate collectors, concentrating collectors – applications - heating, cooling, desalination, drying, cooking, etc. Principle of photovoltaic conversion of solar energy - types of solar cells and fabrication -photovoltaic applications - battery charging, domestic lighting, street lighting.	
MODULE 2 Wind Energy	08 Hrs
Wind Energy- Wind energy - energy chains - application - historical background, merits and limitations - nature of wind - planetary and local day / night winds - wind energy quantum - power in wind- turbine efficiency - torque thrust calculations - velocity at different heights - site selection - components of wind energy conversion system (WECS).	
MODULE 3 Energy from Biomass	08 Hrs
Energy from biomass - biomass as renewable energy source - types of bio mass fuels - solid, liquid and gas - biomass conversion techniques- wet process, dry process photosynthesis - biogas generation - factors affecting bio- digestion - classification of bio gas plant - continuous, batch and fixed dome types - advantages and disadvantages	
MODULE 4 Tidal, Ocean Thermal Energy, Hydel and Geothermal Energy Conversion	08 Hrs
Tidal Energy: tide – spring tide, neap tide – tidal range – tidal power – types of tidal power plant – single and dual basin schemes – requirements in tidal power plant - ocean thermal energy conversion (OTEC): principle - open and closed OTEC cycles - hydel energy: micro hydro - geothermal energy: geothermal energy sources - power plant and environmental issues.	
MODULE 5 New Energy Sources	08 Hrs
Hydrogen as a renewable energy source - sources of hydrogen - fuel for vehicles - hydrogen production - direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production - storage of	

hydrogen - gaseous, cryogenic and metal hydride - fuel cell – principle of working, construction and applications

TEXTBOOKS:

1. Rai.G.D, Non- conventional resources of energy, Khanna publishers, Fourth edition, 2010.
2. Khan. B.H, Non-Conventional Energy Resources, McGraw Hill, Second edition, 2009.

REFERENCES:

1. Rao.S & Parulekar, Energy Technology, Khanna publishers, Fourth edition, 2005.
2. Pai.B.R and Ram Prasad.M.S, Power Generation through Renewable Sources of Energy, Tata McGraw Hill, New Delhi, 1991.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME3611					
TITLE OF THE COURSE	PRODUCT DESIGN AND MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
-	-	-	-

COURSE OBJECTIVES :

- To expose the students the basics of product design and manufacturing
- To introduce students to the basic principles and evaluation methods of various aspects of designing components
- To teach students about the Industrial manufacturability requirements
- To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Analyse the product life cycle phases of any product and suggest appropriate strategies	L2
C02	Construct product planning and specification documents	L3
C03	Demonstrate the knowledge of Architectural and Industrial design aspects of product design	L3
C04	Apply design for excellence (DF-X) concepts in product design	L3
C05	Choose an appropriate manufacturing process for product prototyping.	L4

COURSE CONTENT:	
MODULE 1	08Hrs
Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry -Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies.	
MODULE 2	08Hrs
Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD) Product Specifications: specifications, specifications established, establishing target specifications, setting the final specifications, Case Studies.	
MODULE 3	08Hrs
Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies.	
MODULE 4	08Hrs
Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality) Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design,	

Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies.	
MODULE 5	08Hrs
Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereolithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies.	
TEXT BOOKS: 1. A C Chitale and R C Gupta, Product Design and Manufacturing -, PH1, - 3rd Edition, 2003 REFERENCES: 1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development - McGraw Hill -2000 2. Tim Jones, Butterworth Heinmann, New Product Development - Oxford. UCI - 1997 3. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002	

PROGRAM ELECTIVE – III

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36112					
TITLE OF THE COURSE	ROBOT KINEMATICS AND DYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES :

- To introduce to the control position and orientation of the tool in the three dimensional space.
- To make the student familiar with the joint variables and the position and the orientation of the tool.
- To discuss about creating paths for the tool to follow in order to do useful tasks
- To properly regulate the system's high-speed motion.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To control both the position and orientation of the tool in the three dimensional space.	L2
CO2	The relationship between the joint variables and the position and the orientation of the tool.	L2
CO3	Planning trajectories for the tool to follow on order to perform meaningful tasks.	L3
CO4	To precisely control the high speed motion of the system.	L3
CO5		L3

COURSE CONTENT:

MODULE 1-INTRODUCTION		10Hrs
Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.		
MODULE 2 DIRECT KINEMATICS		08Hrs

Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.	
MODULE 3 INVERSE KINEMATICS	08Hrs
The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.	
MODULE 4 WORKSPACE ANALYSIS AND TRACJECTORY PLANNING	08Hrs
Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique -continuous path motion, Interpolated motion, straight line motion and Cartesian space teclnique in trajectory planning.	
MODULE 5 MANIPULATOR DYNAMICS	08Hrs
Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange Euler formulation, problems.	

TEXT BOOKS :

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009.
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Me Graw Hill Publishing company Ltd., 1995.

REFERENCES :

1. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
2. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house, 1993.
3. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, MIT Press, 2003.
4. John J. Craig, Introduction to Robotics Mechanics and Control, Third Edition, Pearson, 2008.
5. Bijay K. Ghosh, Ning Xi, T.J. Tam, Control in Robtics and Automation Sensor -Based integration, Academic Press, 1999.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36114					
TITLE OF THE COURSE	COMPUTATIONAL TOOLS FOR ADDITIVE MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	48	3

COURSE OBJECTIVES:

- The primary objective of the course is to give students both a practical and a theoretical knowledge of every stage in the additive manufacturing.
- To provide a broad overview of both hardware and software for additive manufacturing
- To introduce to methods for parametric modeling of solid objects that take into account fabrication constraints.
- To cover optimization methods that are applied to automate the design process and additive manufacturing process.
- To cover latest research work in the field of computational fabrication

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to understand and use fundamental computer graphics in the context of design and additive manufacturing	L2
CO2	Students will be able to develop geometric models both parametric and organic using computational geometry techniques	L3
CO3	Students will be able to analyze many instances of recent computational fabrication systems that seamlessly blend parametric modeling, slicing and optimization	L3
CO4	In the second part of the semester, students work in groups on large open-ended projects	L1
CO5	Students will be introduced to case studies of latest research papers in the field of additive manufacturing	L2

COURSE CONTENT:

MODULE 1	08 Hrs
Object Transformations: Object Translation, Object Scaling, Object Rotation, Object Reflection, Object Scaling module	
MODULE 2 Geometric Modeling	08 Hrs
Hermite Curve Design, Hermite Surface Design, Bezier Curve Design, Bezier Surface Design, B-Spline Curve Design, B-Spline Surface Design, Parametric Design	
MODULE 3 Computational geometry	10 Hrs
Convex Hulls: Convexity, The Incremental Algorithm, Analysis of Algorithms, Gift	

Wrapping and Graham Scan, Lower Bound, Divide-and-Conquer; Polygons: Diagonals and Triangulations, Tetrahedralizations, Basic Combinatorics, The Art Gallery Theorem, Scissors Congruence in 2D, Scissors Congruence in 3D; Triangulations: Point Sets, Basic Constructions, Delaunay Triangulations; Voronoi Diagram

MODULE 4 Optimization Methods

08 Hrs

Optimization methods for preprocessing and post processing analysis of geometric models for additive process friendly part builds

MODULE 5

08 Hrs

Case Studies from latest research papers

TEXTBOOKS:

1. Zeid, I. (1991). CAD/CAM theory and practice. McGraw-Hill Higher Education.
- 2.

REFERENCES:

1. Kieran, Stephen, and James Timberlake. Refabricating Architecture: How Manufacturing Methodologies are Poised to Transform Building Construction. New York, NY: McGraw-Hill, 2003. ISBN: 9780071433211.
2. Schodek, Daniel, et al. Digital Design and Manufacturing: CAD/CAM Applications in Architecture and Design. New York, NY: John Wiley & Sons, 2004. ISBN: 9780471456360.
3. Schwalbe, M., 2016. Predictive Theoretical and Computational Approaches for Additive Manufacturing: Proceedings of a Workshop.

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36116					
TITLE OF THE COURSE	HEV / EV SYSTEM DESIGN ARCHITECTURE					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	0	0	-	42	3

COURSE OBJECTIVES:

The course will enable the students to:

- Explain the basics of electric and hybrid electric vehicles, their architecture
- Explain hybrid electric vehicle architecture, design and component sizing in hybrid

electric vehicles.

- Analyze various electric drives suitable for hybrid electric vehicles
- Demonstrate different configurations of electric vehicles and its components.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Students will be able to Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals	L1
C02	Analyse the use of different power electronics devices and electrical machines in hybrid electric vehicles	L3
C03	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology	L1
C04	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis	L2
C05	Understand Energy Management strategies in HEVs	L1

COURSE CONTENT:

MODULE 1 Design & Engineering – xEV	08 Hrs
xEV : micro to mild to PHEV to HEV to REEV to EV - Hybrid-Electric Vehicle Power trains - Vehicle Energy Storage System (VESS) Design - Computational Systems Design (CSD) - Transportation Electrification	
MODULE 2 Introduction to Advanced Electric Vehicles	08 Hrs
Fundamentals of xEVs and key challenges and opportunities of AEV technologies - Engineering philosophy of various xEVs (HEV, PHEV and BEV, REEV)	
MODULE 3 Energy Storage Systems	08 Hrs
Energy storage systems used; Battery electro-chemistry, battery design and	

construction, charging and discharging, power density, Battery interface with motive source	
MODULE 4 Power Electronics for Electric Vehicles & Energy Conversion	08 Hrs
Power electronics including switching, AC-DC, AC-AC conversion, electronic devices and circuits used for control and distribution of electric power Electric Drives / Electromechanical Motors & motive power splitting concepts, and interface within power train system	
MODULE 5 Hybrid Electrical Vehicles	10 Hrs
Introduction - System Overview - Power train architecture - Parallel, Series and Combined - Types of xEVs - Vehicle layout and packaging options. - Energy devices & combinations - examples & Case Studies - Environmental Impact - Regulatory Issues (CO ₂ gas and particulate emissions) - Duty Cycles in Indian cities; performance (off cycle, durability) - Sustainability assessment; cradle to grave environmental impact.	

TEXTBOOKS:

1. Iqbal Husain, "Electric and Hybrid Vehicles –Design Fundamentals", CRC Press
2. Mehrdad Ehsani, Yimin Gao, Sebastian E.Gsay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell vehicles-Fundamentals - Theory and Design", CRC Press

REFERENCES:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 2003
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36117					
TITLE OF THE COURSE	MATERIALS AND MANUFACTURING PROCESSES FOR AUTOMOTIVE SYSTEMS					
Scheme of Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

COURSE OBJECTIVES:

The objectives of the Course are to

- To develop the knowledge of the properties of materials and its alloys
- To introduce the modern materials and alloys.
- To introduce the Surface modification of materials

- To develop knowledge in recent trends in manufacturing techniques of automobile components

COURSE OUTCOMES:

After undergoing this course students will be able to:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand various materials and its alloys are formed and their classification based on atomic arrangement	L2
C02	Describe the mechanical behavior of metallic systems and its importance	L3
C03	Understand the need for modern materials and its alloys.	L3
C04	Gain knowledge on different class of materials, alloys and their manufacturing techniques, applications in automobile field.	L4
C05	Understand the need for Recent Trends in manufacturing Auto components.	L2

COURSE CONTENT:

MODULE 1: Engineering alloys

08Hrs

Ferrous alloys-Iron-Iron carbide phase diagram with all phases & critical temperatures-**steel**, Types of steels-Effect of alloying elements on physical and chemical properties-**Automotive applications**- cast iron-Types-properties-factors affecting structures of cast iron-Automotive application.

Non ferrous alloys- Al, Cu, Tin, Baased alloys, Light metal alloys(mg and Ti)

MODULE 2: Surface modification of materials

08Hrs

Mechanical surface treatment and coating- case hardening and hard facing-thermal spraying-Vapor deposition-ion implantation-diffusion coating-Electroplating and Electro less plating-Conversion coating-Ceramic and Organic coating-Diamond coating-Laser surface treatment-Selection of coating for Automotive applications

MODULE 3: Modern materials and alloys

10Hrs

Super alloys-super plastic alloys for auto body panels-refractory metals-shape memory alloys-dual phase steels-micro alloyed steels-high strength low alloy steels-smart materials -**Composite materials-ceramic** -plastics-introduction, overview of processing, their characteristic features, Types and automotive application-Nanomaterials-Introduction and automotive applications

08Hrs

MODULE 4: Engine materials and manufacturing

Cylinder block and head-cylinder head and gasket-valves, seats and guides-piston and pin-piston ring and liner-con rod-crankshaft and bearing-turbocharger.

Case study: Engine materials used in 4stroke, 2stroke petrol and diesel engine.

MODULE 5: Recent Trends in manufacturing Auto components	08Hrs
Special processing techniques -Hydroforming-stretch forming-Recent developments in auto body panel forming-squeeze casting of pistons, Aluminium composite brake rotors-sinter diffusing bonded idler sprocket-Gas injection moulding of window channel-Cast con process for auto parts-computer modeling and simulation-material characteristics and failure analysis.	

TEXT BOOKS:

1. Callister W.D. (2006) "Material Science and Engineering- An introduction", Wiley –Eastern
2. Flinn R. A. and Trojan P. K., (1999)"Engineering Materials and their Applications", Jaico.

REFERENCES:

1. Avner S.H., (2006) "Introduction to physical metallurgy" –Tata McGraw Hill..
2. Haslehurst.S.E., " Manufacturing Technology ", ELBS, London, 1990

SEMESTER	VI					
YEAR	III					
COURSE CODE	20ME36118					
TITLE OF THE COURSE	INTERNAL COMBUSTION ENGINES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	48	3

Pre-requisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The course will enable the students to:

- To get familiar with the fundamentals of I.C engines, construction and working principle of an engine, and testing of an engine for analysing its performance.
- To study the combustion and its controlling factors in order to design efficient engine
- To study emissions from internal combustion engines and its controlling methods, various emission norms.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student will be able to analyse thermodynamic cycles based on actual conditions.	L3
CO2	Understand operating characteristics of different engine and combustion process for SI and CI engines.	L1
CO3	Understand the different combustion chamber designs and compare for different types fuels used.	L1
CO4	Analyze the emissions in combustion	L3
CO5	Understanding of the various heat transfer mechanisms in the engine	L1

COURSE CONTENT:**MODULE 1 Basics of Internal Combustion Engines****08 Hrs**

Heat engine, internal combustion engines and external combustion engines, internal combustion engine construction - components and materials, engine nomenclature, valve timing diagram, intake and exhaust system, engine classification, applications. Fuel air cycle and actual cycle: fuel air cycle, assumptions, comparison with air standard cycle, effect of variables on performance, actual cycle and various losses.

MODULE 2 Spark Ignition Engines**08Hrs**

Theory of carburetion, types of carburetors, electronic fuel injection system, combustion in spark ignition engines, stages of combustion, flame propagation, rate of pressure rise, abnormal combustion, phenomenon of detonation in spark ignition engines, effect of engine variables on detonation. Combustion chambers, rating of fuels in spark ignition engines, additives.

MODULE 3 Compression Ignition Engines**08 Hrs**

Fuel supply system, types of fuel pump, injector and distribution system, combustion in compression ignition engines, stages of combustion, factors affecting combustion, phenomenon of knocking in compression ignition engine. Effect of knocking, methods of knock control, types of combustion chambers, rating of fuels in compression ignition engines. Dopes & additives, comparison of knocking in spark ignition & compression ignition engines.

MODULE 4 Combustion Chambers	08 Hrs
Requirements of combustion chambers, features of different types of combustion chambers system for S.I. engine. I-head, F-head combustion chambers. C.I. engine combustion chambers-air swirl turbulence, M-type combustion chamber. Comparison of various types of combustion chambers.	
MODULE 5 Internal Combustion Engine-System, Emission and Control	10 Hrs
Internal combustion, Engine Systems: Cooling system, lubrication system, ignition system, governing system, starting system. Internal combustion engine emissions and control air pollution due to internal combustion engine and its effect, emissions from petrol/gas and diesel engines, sources of emissions, euro norms, Bharat stage norms, emission control methods for spark ignition and compression ignition engines.	

TEXTBOOKS:

1. M. L. Mathur and R. P. Sharma , A course in I.C. Engines, , Dhanpat Rai Pub, 2001.
2. Colin R. Ferguson C, Internal Combustion Engines, John Wiley & sons, 1986

REFERENCES:

1. Heywood, Internal Combustion Engine Fundamentals, Tata McGraw-Hill, 2011
2. V. Ganesan, Internal Combustion Engines, Tata McGraw-Hill, 2012

OPEN ELECTIVE - I

SEMESTER	V					
YEAR	III					
COURSE CODE	200E0015					
TITLE OF THE COURSE	AUTOMOBILE ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To understand basics of Automobile Engineering & various automotive system.
- To understand vehicle layout, vehicle specifications & important of automobile.
- To make the student conversant with drive train & transmission.
- Understand the various Automobile Electrical System, Vehicle performance & their safety

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain components of automotive vehicle	L1
C02	Describe functioning of automotive transmission system	L1
C03	Calculate the resistance offered to the automobile by various factors	L2
C04	Describe various electrical components used in automobiles	L1
C05	Diagnosis the faults of automobile vehicles.	L2

COURSE CONTENT:	
MODULE 1	08Hrs
	s

Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.

MODULE 1	08Hrs
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	
MODULE 2	08Hrs
Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission, Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive.	
MODULE 3	10Hrs
Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. Suspension: Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), damping and shock absorbers Brakes: Types of brake systems - drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.	
MODULE 4	08Hrs
Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise.	
MODULE 5	08Hrs
Batteries: Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods. Lighting System & Accessories: Insulated & earth return systems, positive & negative earth systems, electrical fuel pump, speedometer, fuel, oil & temperature gauges, horn, wiper system, trafficator, sensors and actuators, electronic control unit, traction control devices. Vehicle maintenance Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system.	

TEXT BOOKS :

1. William H. Crouse., "Automotive Mechanics", Tata McGraw Hill Publishing House.

REFERENCES :

1. K. Newton and W. Seeds, T.K. Garrett, "Motor Vehicle", 13th Edition, Elsevier publications
2. Hans Hermann Braess, Ulrich Seiffen, "Handbook of Automotive Engineering ", SAE Publications

SEMESTER	V					
YEAR	III					
COURSE CODE	200E0016					
TITLE OF THE COURSE	RAPID MANUFACTURING TECHNOLOGIES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To provide knowledge of methods for the manufacturing of prototypes from computer based models
- To understand the entire process of direct manufacturing from the creation of computer based models to their physical realization
- To understand the various methods of manufacturing and their merits, demerits and applications
- To impart students to convert CAD models into real life engineering components

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the various rapid prototyping technologies ,	L1
C02	Select appropriate technology for product development	L2
C03	Describe rapid prototyping techniques	L1
C04	Analyse the quality of a product using rapid prototyping technique	L3
C05	Describe application of rapid prototyping	L1

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction- Need for the compression in product development, Historical development, Fundamentals of RP, Advantages and Classification of RP systems. Process chain, RP Data	

Formats, Information flow in an RP system.	
MODULE 2	10Hrs
Stereo lithography Apparatus (SLA): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Solid ground curing (SGC): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications.	
MODULE 3	10Hrs
Fused Deposition Modelling (FDM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Laminated Object Manufacturing (LOM): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Ballistic Particle Manufacturing (BPM): Principle.	
MODULE 4	10Hrs
Selective laser sintering (SLS): Principle, process parameters, process details, machine details, products, Advantages, Limitations and applications. Three dimensional Printing (3DP): Principle, process parameters, process details, machine details, products, Advantages, Limitations, applications. Laser Engineering Net Shaping (LENS) - Principle. Concept modellers like thermal jet printers, Sander's model maker, GenisysXs 3D printers, JP system 5, Object Quadra system.	
MODULE 5	10Hrs
Introduction to rapid tooling: Direct soft tooling- casting molds, Direct AIM, composite tooling. Indirect soft tooling- spray metal molding, silicon rubber molds, Castable resin and ceramic molds. Direct hard tooling-rapid tool, Laminated metal tooling, DMLS tooling. Indirect hard tooling- 3D keltool, ED electrodes, Ecotool, copy milling. Applications: Application-Material Relationship, Applications in Design, Applications in Engineering, Analysis and Planning. Application of Rapid prototyping in biomedical, automotive, aerospace, jewellery and coin industries.	

TEXT BOOKS :

1. C. K.Chua, K. F.Leong and C. S.Lim, Rapid prototyping: Principles and applications, World Scientific Publishers, 2003

REFERENCES :

1. Andreas Gebhardt, Hanser , Rapid prototyping, Gardener Publications, 2003.
2. L.W.Liou, F.W. Liou, Rapid Prototyping and Engineering applications: A tool box for prototype development,

OPEN ELECTIVE – II

SEMESTER	VI					
YEAR	III					
COURSE CODE	200E0017					
TITLE OF THE COURSE	ROBOTICS ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To introduce the basic concepts, parts and types of robots.
- To make the student familiar with the various sensors, drive systems in robots and programming.
- To discuss about the various applications, justification and implementation of robot.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Explain the basic principles of Robotic technology, configurations, control and programming of Robots	L2
C02	Describe the concept of Robot kinematics and dynamics, algorithms & analytical approaches	L2
C03	To choose the appropriate Sensor and Machine vision system for a given application	L3
C04	Design an industrial robot which can meet kinematic and dynamic constraints.	L3
C05	Apply the manipulator kinematics and trajectory generation concepts	L3

COURSE CONTENT:	
MODULE 1	10Hrs
Historical back ground, definitions, robot anatomy, robot configurations, coordinate system, work envelop, specifications and classification of robots, flexible automation versus robotic technology, dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. Applications of robots- material	

transfer, machine loading / unloading, welding, assembly and spray painting operations.	
MODULE 2	08Hrs
Positions, orientations and frames, mappings, operators. Translations, rotations and transformations - homogeneous transformations, kinematics equation using homogeneous transformations, composite rotation matrix, D-H representation - forward and inverse kinematics, robot arm dynamics. Euler angle & Euler transformations, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 3	08Hrs
Drive system, control system, robot drive mechanisms, hydraulic - electric - servomotor- stepper motor - pneumatic drives, mechanical transmission method - gear transmission, belt drives, cables, roller chains, link - rod systems - rotary-to-rotary motion conversion, rotary-to-linear motion conversion, rack and pinion drives, lead screws, ball bearing screws.	
MODULE 4	08Hrs
Various sensors and their classification, use of sensors, transducers, sensors in robotics and their classification, touch, proximity and range sensors, force and torque sensing, robotic assembly and intelligent sensors. Machine vision system, description, sensing, digitizing, image processing and analysis, application of machine vision system.	
MODULE 5	08Hrs
Basic structure of trajectory interpolators, trajectory planning and avoidance of obstacles, path planning, skew motion, joint integrated motion – straight line motion, general design consideration on trajectories. Robot languages- lead through method, VAL systems, robot program as a path in space, methods of defining positions in space, motion interpolation, branching, textual robot programming languages, off line programming systems.	

TEXT BOOKS :

1. AshitavaGhosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES :

1. Fu, K. S, Gonzalez, R. C, Lee, C.S.G, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987
2. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	VI					
YEAR	III					
COURSE CODE	200E0018					
TITLE OF THE COURSE	PRODUCT DESIGN AND MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	42	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To expose the students the basics of product design and manufacturing.
- To introduce students to the basic principles and evaluation methods of various aspects of designing components.
- To teach students about the Industrial manufacturability requirements.
- To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Analyse the product life cycle phases of any product and suggest appropriate strategies	L2
C02	Construct product planning and specification documents	L3
C03	Demonstrate the knowledge of Architectural and Industrial design aspects of product design	L3
C04	Apply design for excellence (DF-X) concepts in product design	L3
C05	Choose an appropriate manufacturing process for product prototyping.	L4

COURSE CONTENT:	
MODULE 1	10Hrs
Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry -Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies	

MODULE 2	08Hrs
Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD) Product Specifications: specifications, specifications established, establishing target specifications, setting the final specifications, Case Studies	
MODULE 3	08Hrs
Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies	
MODULE 4	08Hrs
Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies	
MODULE 5	08Hrs
Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereolithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies.	

TEXT BOOKS :

1. A C Chitale and R C Gupta, Product Design and Manufacturing -, PH1, - 3rd Edition, 2003

REFERENCES :

1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development - McGraw Hill -2000.
2. Tim Jones, Butterworth Heinmann, New Product Development - Oxford. UCI - 1997
3. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002
3. J.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4701					
TITLE OF THE COURSE	CONTROL SYSTEMS ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	2	-	65	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- Gain a thorough understanding of the principles and theories behind control systems.
- Develop the ability to analyze control systems in both the time and frequency domains.
- Acquire skills to design and tune controllers to meet specific performance requirements.
- Master the state space analysis method for a better understanding of control system characteristics.

COURSE OUTCOMES :

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply fundamental control theory principles to model complex mechanical systems using transfer functions and state-space methods.	L3
CO2	Implement time and frequency domain techniques to analyze the stability and performance of control systems.	L4
CO3	Design and tune controllers, such as PID controllers and compensators, to enhance system performance and stability.	L3
CO4	Apply root locus and frequency domain methods for the design and tuning of control systems.	L3
CO5	Implement state space analysis to determine system controllability, observability, and stability.	L4
CO6	Use computer software tools, such as MATLAB or Simulink, to simulate and analyze the behavior of control systems.	L3

COURSE CONTENT:	
MODULE 1	07Hrs
Introduction to Control Systems includes basics of control systems, differentiation between open loop and closed loop systems, system modeling using transfer functions and state space, along with block diagrams and signal flow graphs.	
MODULE 2	08Hrs

Time Domain Analysis introduces standard test signals, time response of first and second order systems, time domain specifications, steady-state errors, and stability analysis using the Routh-Hurwitz Criterion.	
MODULE 3	08Hrs
Frequency Domain Analysis consists of understanding the correlation between time and frequency response, usage of Bode and Nyquist plots, and stability analysis in the frequency domain through the Nyquist Criterion, gain and phase margins.	
MODULE 4	08Hrs
Design of Control Systems focuses on learning compensation techniques such as lead, lag, and lead-lag compensators, design of PID controllers, root locus technique, and frequency domain design with design specifications and performance indices.	
MODULE 5	08Hrs
State Space Analysis entails learning about the concept of state, state variables, state model, solutions to state equations, controllability, observability, pole placement design, and quadratic optimal control systems.	

Lab Component (26 hours):

Lab 1: Introduction to Control Systems - 4 hours

Software-based simulation to understand the basics of open and closed-loop control systems. Understanding transfer function and state-space representation of systems through modeling.

Lab 2: Time Domain Analysis - 5 hours

Experimental study of the response of first and second-order systems for standard test signals. Implementing Routh-Hurwitz criterion to determine system stability.

Lab 3: Frequency Domain Analysis - 5 hours

Plotting and interpreting Bode and Nyquist plots. Applying Nyquist criterion to analyze system stability.

Lab 4: Design of Control Systems - 6 hours

Designing and tuning of a PID controller for a given system. Use of root locus method for system design.

Lab 5: State Space Analysis - 6 hours

Conducting state-space analysis for control systems. Observability and controllability analysis for given systems.

Textbooks:

- Nise, N. S., "Control Systems Engineering", 8th Edition, Wiley, 2019.
- Ogata, K., "Modern Control Engineering", 5th Edition, Prentice Hall, 2009.

References:

- Dorf, R. C., and Bishop, R. H., "Modern Control Systems", 13th Edition, Pearson, 2016.
- Franklin, G. F., Powell, J. D., and Emami-Naeini, A., "Feedback Control of Dynamic Systems", 8th Edition, Pearson, 2019.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4703					
TITLE OF THE COURSE	INDUSTRIAL AUTOMATION – II					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

1. To deepen students' understanding of the role of advanced Industrial IoT (IIoT) systems in industrial automation.
2. To develop proficiency in integrating vision systems and sensors into automation processes for improved efficacy.
3. To provide a detailed understanding of advanced robotics, machine learning, and AI applications in the realm of industrial automation.
4. To familiarize students with the principles of Industry 4.0, digital twin technology, and their significance in the digital transformation of manufacturing.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Implement advanced Industrial IoT (IIoT) concepts, including cloud and edge computing solutions, in modern industrial automation setups.	L4
CO2	Use knowledge of vision systems and sensors to analyze their role and effectiveness in automation processes.	L3
CO3	Apply principles of advanced robotics, including robot kinematics, dynamics, trajectory planning, and multi-robot systems, to enhance automation efficiency.	L3
CO4	Develop machine learning models to solve automation problems and use artificial intelligence techniques to optimize industrial processes.	L4

CO5	Assess the implications of Industry 4.0 principles and digital twin technology in the digital transformation of manufacturing.	L3
CO6	Utilize advanced simulation and modeling techniques to design and improve automated systems.	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Advanced Industrial IoT (IIoT): exploration into Industrial IoT (IIoT) applications in modern industrial automation, including cloud computing, edge computing, cybersecurity in IIoT, and advanced analytics and machine learning for predictive maintenance and quality control.	
MODULE 2	08Hrs
Vision Systems and Sensors in Automation: Introduction to the role of vision systems and sensors in automation. Topics include machine vision, sensor integration with automation systems, data acquisition, and sensor fusion.	
MODULE 3	08Hrs
Advanced Robotics: advanced topics in robotics, including robot kinematics, dynamics, and trajectory planning. The module also covers AI integration in robotics, multi-robot systems, and swarm robotics.	
MODULE 4	07Hrs
Machine Learning and AI in Industrial Automation: application of machine learning and artificial intelligence in industrial automation. Topics include predictive modeling, neural networks and AI-driven optimization of manufacturing processes.	
MODULE 5	08Hrs
Industry 4.0 and Digital Twin Technology: This module focuses on the principles of Industry 4.0, the digital transformation of manufacturing, and the application of digital twin technology in product lifecycle management.	

Textbooks:

Maynard, H. B., "Maynard's Industrial Engineering Handbook", 5th Edition, McGraw-Hill, 2001.

Craig, J.J., "Introduction to Robotics: Mechanics and Control", 4th Edition, Pearson, 2017.

References:

Esposito, A., "Artificial Intelligence and Robotics", Springer, 2020.

Sikora, R., "Industry 4.0: Industrial Revolution of the 21st Century", Springer, 2019.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4704					
TITLE OF THE COURSE	AUTOMATION SYSTEM DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To provide students with a comprehensive understanding of the principles of automation system design.
- To develop skills in designing efficient automated manufacturing systems and implementing material handling and storage solutions.
- To familiarize students with the application of control systems like PLCs, DCS, and SCADA in automation.
- To equip students with the knowledge of simulation techniques and optimization methods for enhancing the efficiency and productivity of automated systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply the fundamental concepts of automation system design to develop efficient automated solutions.	L3
CO2	Design automated manufacturing systems, including work cells and assembly lines, while considering factors like assembly, testing, and inspection.	L4
CO3	Utilize different types of material handling and storage systems, including automated guided vehicles, conveyors, and automated storage and retrieval systems.	L3
CO4	Implement control systems like programmable logic controllers (PLCs), Distributed Control Systems (DCS), and Supervisory Control and Data Acquisition (SCADA) in automation system design.	L4
CO5	Use simulation techniques effectively for understanding the behavior of automated systems.	L3
CO6	Apply optimization methods to improve the efficiency and productivity of automated systems.	L3

COURSE CONTENT:

MODULE 1	08Hrs
Fundamentals of Automation System Design delves into the basic concepts of automation, system design, and life cycle. This module also provides an overview of different types of automation systems such as fixed, programmable, and flexible systems.	
MODULE 2	08Hrs
Design of Automated Manufacturing Systems, students learn about the concepts of production system design, work cells, assembly lines, and the design strategies for automated assembly, testing, and inspection.	
MODULE 3	08Hrs
Material Handling and Storage Systems covers various types of material handling and storage systems, including the use of automated guided vehicles, conveyors, and automated storage and retrieval systems in modern manufacturing.	
MODULE 4	07Hrs
Control Systems and PLCs delves into the role of control systems in automation. Here, students gain knowledge on programmable logic controllers (PLCs), Distributed Control Systems (DCS), and Supervisory Control and Data Acquisition (SCADA) systems.	
MODULE 5	08Hrs
Simulation and Optimization of Automated Systems introduces students to various simulation techniques for automated systems, and the methods to optimize these systems for better efficiency and productivity.	

Textbooks:

Groover, M. P., "Automation, Production Systems, and Computer-Integrated Manufacturing", 4th Edition, Prentice Hall, 2014.

Bolton, W., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 6th Edition, Pearson, 2015.

References:

Harris, C. M., "Handbook of Automation, Computation, and Control", Volume 2: Systems and Components, 2013.

Shelly, G. B., and Rosenblatt, H. J., "Systems Analysis and Design", 10th Edition, Cengage Learning, 2014. (Useful for its content on system design methodologies and practices)

SEMESTER	VII

YEAR	IV					
COURSE CODE	20ME4705					
TITLE OF THE COURSE	INDUSTRY 4.0 and IOT					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To provide students with an in-depth understanding of Industry 4.0 and IoT and their transformative impact on the industrial sector.
- To develop practical skills in using key IIoT technologies and implementing cyber-physical systems and digital twin technology.
- To equip students with knowledge in data analytics, machine learning, and AI, and their applications in Industry 4.0.
- To cultivate awareness of cybersecurity challenges in Industry 4.0 and strategies to mitigate potential risks.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply the concepts of Industry 4.0 and Internet of Things (IoT) to understand and address industrial challenges.	L3
CO2	Utilize key Industrial IoT (IIoT) technologies such as sensors, actuators, embedded systems, and wireless communication in industrial settings.	L4
CO3	Design and implement cyber-physical systems and digital twin technology in industry-related projects.	L3
CO4	Leverage data analytics, machine learning, and AI to solve complex industrial problems and optimize manufacturing processes.	L4
CO5	Identify common cybersecurity threats in Industry 4.0 and propose strategies to protect industrial systems.	L3
CO6	Analyze and evaluate the impact of Industry 4.0 and IoT on the future of manufacturing and industrial operations.	L3

COURSE CONTENT:	
MODULE 1	08Hrs

Introduction to Industry 4.0 and IoT gives a comprehensive overview of the key concepts and technologies driving Industry 4.0 and Internet of Things (IoT). Topics include the evolution of the industrial revolution, principles of Industry 4.0, the role of IoT in the industry, and an introduction to Industrial IoT (IIoT).	
MODULE 2	08Hrs
IIoT Technologies covers the critical technologies in IIoT, such as sensors and actuators, embedded systems, wireless communication, cloud computing, edge computing, and data analytics.	
MODULE 3	08Hrs
Cyber-Physical Systems and Digital Twin Technology introduces students to the principles of cyber-physical systems and digital twin technology. This module includes the design, implementation, and applications of these systems in the industry.	
MODULE 4	07Hrs
Data Analytics and AI in Industry 4.0 delves into the role of data analytics and AI in Industry 4.0. It covers topics such as predictive analytics, machine learning, and AI-driven optimization in manufacturing.	
MODULE 5	08Hrs
Cybersecurity in Industry 4.0 concludes the course by addressing the critical aspect of cybersecurity in Industry 4.0. It provides an understanding of common security threats, vulnerabilities, and strategies to protect industrial systems.	

Textbooks:

Lu, Y., "Industry 4.0: A Survey on Technologies, Applications and Open Research Issues", Journal of Industrial Information Integration, 2017.

Greengard, S., "The Internet of Things", The MIT Press Essential Knowledge Series, 2015.

References:

Hermann, M., Pentek, T., and Otto, B., "Design Principles for Industrie 4.0 Scenarios, 2016.

Vermesan, O., and Friess, P., "Internet of Things: From Research and Innovation to Market Deployment", River Publishers, 2014.

SEMESTER	VII
YEAR	IV
COURSE CODE	20ME4706

TITLE OF THE COURSE	CAD/CAM for AM					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To introduce students to the principles of CAD/CAM in the context of additive manufacturing and guide them towards mastering these tools.
- To enhance practical skills in designing 3D models using advanced CAD techniques suitable for additive manufacturing processes.
- To equip students with the ability to plan and execute CAM processes, as well as to carry out post-processing and validation of printed parts.
- To facilitate an understanding of the applications of additive manufacturing across industries and to analyze real-world case studies effectively.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply fundamental and advanced CAD/CAM concepts in the context of additive manufacturing.	L3
CO2	Utilize advanced CAD techniques to design complex 3D models tailored for additive manufacturing processes.	L4
CO3	Plan and execute CAM processes for additive manufacturing, including toolpath generation, process parameter selection, and slicing algorithms.	L3
CO4	Implement post-processing methods in additive manufacturing and validate the quality of printed parts through non-destructive testing, dimensional inspection, and mechanical testing.	L4
CO5	Understand and apply the principles of additive manufacturing in various industrial applications.	L3
CO6	Analyze and critique real-world case studies where CAD/CAM is effectively used in additive manufacturing scenarios.	L3

COURSE CONTENT:	
MODULE 1	08Hrs

Introduction to CAD/CAM and Additive Manufacturing introduces the fundamental concepts of CAD/CAM, additive manufacturing technologies, and the role of CAD/CAM in the additive manufacturing process.	
MODULE 2	08Hrs
Advanced CAD Design for Additive Manufacturing covers advanced CAD techniques including 3D modeling, assemblies, and designing for additive manufacturing, with considerations for part orientation, support structures, and material usage.	
MODULE 3	08Hrs
CAM and Process Planning for Additive Manufacturing discusses topics such as toolpath generation, process parameters, slicing algorithms, and build strategies in the context of additive manufacturing.	
MODULE 4	07Hrs
Post-processing and Validation in Additive Manufacturing covers post-processing methods in additive manufacturing, as well as the techniques for validating the printed parts such as non-destructive testing, dimensional inspection, and mechanical testing.	
MODULE 5	08Hrs
Applications and Case Studies in Additive Manufacturing concludes the course by exploring various applications of additive manufacturing in different industries, followed by case studies where CAD/CAM is used effectively in additive manufacturing scenarios.	

Textbooks:

Gibson, I., Rosen, D.W., and Stucker, B., "Additive Manufacturing Technologies", Springer, 2015.

Zeid, I., "Mastering CAD/CAM", McGraw-Hill, 2004.

References:

Wong, K. V., and Hernandez, A., "A Review of Additive Manufacturing", ISRN Mechanical Engineering, 2012.

Bártolo, P. J., "Stereolithography: Materials, Processes and Applications", Springer, 2011.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4707					
TITLE OF THE COURSE	VEHICLE DYNAMICS AND ADVANCED POWERTRAIN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To equip students with a comprehensive understanding of vehicle dynamics and the principles of powertrain systems.
- To develop practical skills in vehicle ride comfort and handling through the study of suspension systems and stability controls.
- To provide insights into advanced powertrain technologies and their implementation in modern vehicle design.
- To foster an understanding of powertrain integration and its effects on vehicle performance, emissions, and fuel economy, promoting sustainable practices in automotive engineering.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply fundamental principles of vehicle dynamics to analyze and address real-world problems related to forces, moments, tire dynamics, and vehicle motion.	L3
CO2	Implement concepts of vehicle ride comfort and handling in the design and improvement of suspension systems and vehicle stability controls.	L4
CO3	Design and optimize powertrain systems by considering the role of various components in vehicle performance.	L3
CO4	Incorporate advanced powertrain technologies such as hybrid and electric powertrains, fuel cell technologies, and energy storage systems into vehicle designs.	L4
CO5	Develop strategies for the integration of powertrain systems into the overall vehicle architecture, considering the impacts on vehicle performance.	L3
CO6	Assess and optimize the role of powertrain systems in emissions and fuel economy, employing sustainable practices in powertrain design.	L3

COURSE CONTENT:	
MODULE 1	08Hrs

Introduction to Vehicle Dynamics offers an overview of the fundamental principles of vehicle dynamics. It includes topics such as forces and moments, tire dynamics, and vehicle motion (longitudinal, lateral, and vertical).	
MODULE 2	08Hrs
Vehicle Ride and Handling delves deeper into vehicle dynamics with a focus on ride comfort and handling. Students will learn about suspension systems, steering dynamics, and vehicle stability control systems.	
MODULE 3	08Hrs
Basics of Powertrain Systems introduces the basics of powertrain systems. It covers topics such as engine operation, transmission systems, drivetrain components, and the role of powertrain in vehicle performance.	
MODULE 4	07Hrs
Advanced Powertrain Technologies provides insight into the latest advancements in powertrain technologies. This includes hybrid and electric powertrains, fuel cell technologies, and energy storage systems.	
MODULE 5	08Hrs
Powertrain Integration and Vehicle Performance concludes the course with a focus on the integration of powertrain systems into the overall vehicle architecture and its impact on vehicle performance. Topics include powertrain control strategies, emissions, and fuel economy.	

Textbooks:

Gillespie, T.D., "Fundamentals of Vehicle Dynamics", Society of Automotive Engineers Inc., 1992.

Stone, R., "Introduction to Internal Combustion Engines", 4th Edition, Palgrave, 2012.

References:

Wong, J. Y., "Theory of Ground Vehicles", 4th Edition, Wiley, 2008.

Heywood, J. B., "Internal Combustion Engine Fundamentals", McGraw Hill, 1988.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4708					
TITLE OF THE COURSE	ADVANCED ENERGY STORAGE					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)

#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To provide comprehensive knowledge about various energy storage systems
- To develop skills in evaluating and designing energy storage systems
- To introduce emerging technologies in energy storage and their practical applications
- To foster understanding of the integration, management, and economic aspects of energy storage systems

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply knowledge of various energy storage systems.	L3
CO2	Evaluate mechanical and thermal energy storage systems.	L4
CO3	Design electrochemical energy storage systems.	L3
CO4	Implement emerging energy storage technologies in practical scenarios.	L4
CO5	Assess integration strategies for energy storage.	L3
CO6	Formulate energy storage management plans.	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Fundamental concepts of energy storage, an overview of different technologies, and an understanding of the role and importance of energy storage in modern power systems.	
MODULE 2	08Hrs
Specific types of mechanical energy storage systems like Pumped Hydro Storage (PHS) and Compressed Air Energy Storage (CAES). The module will also delve into thermal energy storage technologies, highlighting their principles, types, and applications.	
MODULE 3	08Hrs
Batteries and supercapacitors, both fundamental components of electrochemical energy storage, different battery technologies and their performance, lifespan, safety, and environmental considerations.	

MODULE 4	07Hrs
Generation of energy storage technologies, including hydrogen storage, fuel cells, and advanced battery systems. Latest innovations in thermal and kinetic energy storage.	
MODULE 5	08Hrs
Integration of storage technologies into renewable energy systems. Economic and regulatory considerations surrounding energy storage and its role in grid services.	

Textbooks:

- "Energy Storage" by Robert Huggins. Publisher: Springer; 2016 edition.
- "Electrochemical Energy Storage for Renewable Sources and Grid Balancing" by Patrick T. Moseley and Jurgen Garche. Publisher: Elsevier; 2015 edition.

Reference book:

- "Advances in Batteries for Medium and Large-Scale Energy Storage" edited by Chris Menictas, Maria Skyllas-Kazacos, and Tuti Mariana Lim. Publisher: Woodhead Publishing; 2015 edition.
- "The Handbook of Lithium-Ion Battery Pack Design" by John Warner. Publisher: Elsevier; 2015 edition.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4709					
TITLE OF THE COURSE	COMPUTATIONAL FLUID DYNAMICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- Introduce Governing Equations of viscous fluid flows

- Introduce numerical modelling and its role in the field of fluid flow and heat transfer
- Enable the students to understand the various discretization methods, solution procedures and turbulence modelling.
- Create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Solve Fluid Dynamics Problems Using Governing Equations.	L3
CO2	Implement Finite Difference and Finite Volume Methods.	L4
CO3	Apply Finite Volume Method for Convection Diffusion.	L3
CO4	Perform Flow Field Analysis.	L4
CO5	Utilize Turbulence Models.	L3
CO6	Generate Mesh for CFD Analyses.	L3

COURSE CONTENT:	
MODULE 1	
08Hrs	
Governing equations and boundary conditions: Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent-Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.	
MODULE 2	
08Hrs	
Finite difference and finite volume methods for diffusion: Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three – dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.	
MODULE 3	
08Hrs	
Finite volume method for convection diffusion: Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.	
MODULE 4	
07Hrs	

Flow field analysis: Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.	
MODULE 5	08Hrs
Turbulence models and mesh generation: Turbulence models, mixing length model, Two equation (k- ϵ) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools	

Text books

- Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Second Edition Pearson Education Ltd. 2007.
- Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.

Reference books

- Patankar, S.V. "Numerical Heat Transfer and Fluid Flow, Hemisphere" Publishing Corporation, 2004.
- Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, 2002.
- Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005
- Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4710					
TITLE OF THE COURSE	OPERATIONS MANAGEMENT					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES:

- To equip students with fundamental knowledge and skills in operations management
- To develop proficiency in process analysis and improvement techniques
- To provide understanding and application skills in supply chain and logistics

management

- To instill competence in capacity and production planning, project management, and operations management in the service sector

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply Principles of Operations Management.	L3
CO2	Utilize Process Analysis and Improvement Techniques.	L4
CO3	Optimize Supply Chain and Logistics Management Strategies.	L3
CO4	Implement Capacity and Production Planning Techniques.	L4
CO5	Execute Effective Project Management.	L3
CO6	Implement Operations Management in Service Sector.	L3

COURSE CONTENT:	
MODULE 1	08Hrs
Introduction to Operations Management : Overview of operations management – Definitions and terminologies – Role of operations in organizational strategy – Operations strategy and competitiveness – Decision making in operations management.	
MODULE 2	08Hrs
Process Analysis and Improvement Concept of process – Process mapping and flowchart – Process performance metrics – Process improvement techniques – Lean principles and Six Sigma – Quality management and statistical process control.	
MODULE 3	08Hrs
Supply Chain and Logistics Management Introduction to supply chain management – Role of logistics in operations – Strategic and operational issues in supply chain management – Inventory management – Techniques for demand forecasting.	
MODULE 4	07Hrs
Capacity and Production Planning Capacity planning strategies – Factors affecting capacity decisions – Production planning methods: MRP, ERP, JIT – Workforce planning and scheduling – Facility location and layout planning.	
MODULE 5	08Hrs

Project and Operations Management in Services Concept of project management – Project planning and control – Critical path method (CPM) and Program Evaluation and Review Technique (PERT) – Operations management in services: characteristics, service delivery process, service quality management.

Textbooks:

"Operations Management" by William J. Stevenson. Publisher: McGraw-Hill/Irwin; 13th edition.

"Operations Management: Processes and Supply Chains" by Lee J. Krajewski, Manoj K. Malhotra, and Larry P. Ritzman. Publisher: Pearson; 12th edition.

Reference Materials:

"Production and Operations Management" by S.N. Chary. Publisher: McGraw-Hill; 6th edition.

"The Goal: A Process of Ongoing Improvement" by Eliyahu M. Goldratt and Jeff Cox. Publisher: North River Press; 30th Anniversary edition.

PROGRAM ELECTIVE – V

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4711					
TITLE OF THE COURSE	Robot Vision Systems					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To introduce students to the fundamentals of robot vision systems and their role in robotics and automation.
- To provide an understanding of the key concepts, techniques, and algorithms used in robot vision systems.
- To enable students to design, implement, and evaluate vision-based solutions for various robotic applications.
- To develop critical thinking and problem-solving skills in the context of robot vision

systems.

- To explore the challenges and future trends in the field of robot vision systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Implement Image Processing Techniques in Robot Vision Systems.	L4
CO2	Develop Object Detection and Recognition Algorithms.	L3
CO3	Apply 3D Vision Techniques in Robotics.	L3
CO4	Design and Implement Navigation and Mapping Systems.	L3
CO5	Develop Vision-Based Grasping and Manipulation Techniques.	L4
CO6	Integrate Human-Robot Interaction into Robot Vision Systems.	L3

COURSE CONTENT:	
Module 1: Introduction to Robot Vision Systems	
08Hrs	
Course Overview, History and Evolution of Robot Vision Systems, Importance and Applications of Robot Vision in Robotics, Components of a Robot Vision System, Sensors and Perception in Robots, Introduction to Image Processing and Analysis	
MODULE 2	
08Hrs	
Image Formation and Image Sensing, Image Preprocessing Techniques (Filtering, Enhancement, etc.), Image Segmentation, Feature Extraction Techniques (Edges, Corners, Descriptors, etc.), Image Representation and Feature Encoding, Hands-on lab sessions using image processing libraries	
MODULE 3	
08Hrs	
Object Detection vs. Object Recognition, Image Feature Matching Template Matching Object Detection using Machine Learning (e.g., Haar cascades, CNNs), Object Recognition using Deep Learning, Practical exercises on object detection and recognition algorithms	
MODULE 4	
07Hrs	
Depth Perception and Stereopsis Structured Light and Time-of-Flight Cameras, 3D Point Cloud Processing, 3D Object Reconstruction and Pose Estimation, Scene Understanding and Semantic Segmentation, Hands-on lab sessions on 3D vision techniques	
MODULE 5	
08Hrs	

Robot Navigation and Mapping using Vision, Grasping and Manipulation with Robot Vision, Vision-based Localization and Simultaneous Localization and Mapping (SLAM), Human-Robot Interaction and Social Robot Vision, Ethical Considerations in Robot Vision Systems, Emerging Trends and Future Directions in Robot Vision	

TEXT BOOKS:

1. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

REFERENCES:

3. F.L. Lewis, D.M. Dawson, and C.T. Abdallah, Robot Manipulator Control: Theory and Practice, Revised and Expanded, Marcel Dekker, New York, 2004..
4. Richard D. Klafter, Robotic Engineering, Prentice Hall of India Pvt., Ltd., 2001.

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4712					
TITLE OF THE COURSE	ROBOT PROGRAMMING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To introduce students to the fundamental concepts and principles of robot programming.
- To familiarize students with different programming languages and platforms commonly used in robotics.
- To provide hands-on experience in designing, implementing, and debugging robot programs.
- To enable students to develop robot behaviors and control strategies for various robotic

systems.

- To foster problem-solving skills and algorithmic thinking in the context of robot programming.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Select appropriate programming languages and platforms for specific robotic applications.	L2
CO2	Design and implement robot behaviors and control strategies using various techniques.	L2
CO3	Apply behavior-based and reactive approaches to control robots in dynamic environments.	L3
CO4	Create and execute a complete robot programming project, including simulation and testing.	L3
CO5	Analyze and optimize robot programs for improved performance.	L3

COURSE CONTENT:	
Module 1: Introduction to Robot Programming	08Hrs
Course Overview, Importance and Role of Robot Programming in Robotics, Types of Robots and Robot Programming Paradigms, Robot Programming Languages (e.g., C/C++, Python, ROS), Robot Operating Systems (ROS) Basics, Hands-on: Setting up the programming environment	
Module 2: Robot Perception and Sensing	08Hrs
Understanding Robot Sensors and Actuators, Interfacing with Robot Hardware, Processing Sensor Data for Perception, Introduction to Robot Vision and Image Processing, Sensor Fusion and Multi-sensor Integration Practical exercises on working with robot sensors	
Module 3: Robot Motion Planning and Control	08Hrs
Kinematics and Dynamics of Robotic Systems Robot Motion Planning Techniques (e.g., Path Planning, Trajectory Generation) Obstacle Avoidance and Collision Detection, PID Control and Feedback Loops, Introduction to Inverse Kinematics and Control, Hands-on: Implementing basic robot motions and control algorithms	
Module 4: Behavior-based and Reactive Robotics	07Hrs
Behavior-based Paradigm in Robotics, Finite State Machines for Robot Behavior Control, Reactive Systems and Behavior Arbitration, Multi-Robot Systems and Coordination, Introduction to Reinforcement Learning in Robotics, Practical exercises on behavior-based robot programming	
Module 5: Robot Applications and Project Development	08Hrs

Robot Programming for Specific Applications (e.g., Mobile Robotics, Manipulators), Project Planning and Designing Robot Behaviors, Robot Simulation and Testing, Project Implementation, Debugging, and Optimization Project Presentations and Demonstrations, Future Trends and Advanced Topics in Robot Programming	

TEXT BOOKS:

1. "Programming Robots with ROS: A Practical Introduction to the Robot Operating System" by Morgan Quigley, Brian Gerkey, William D. Smart.
2. Robotics, Vision and Control: Fundamental Algorithms in MATLAB" by Peter Corke.

REFERENCES:

1. Modern Robotics: Mechanics, Planning, and Control" by Kevin M. Lynch, Frank C. Park - An in-depth treatment of robot mechanics, planning algorithms, and control theory.
2. Robot Dynamics and Control" by Mark W. Spong, Seth Hutchinson, M. Vidyasagar

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4713					
TITLE OF THE COURSE	Intelligent Manufacturing Systems					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- To introduce students to the principles, concepts, and technologies underlying intelligent manufacturing systems.
- To develop an understanding of how advanced technologies such as AI, IoT, and robotics can be integrated to optimize manufacturing processes.
- To familiarize students with the challenges and opportunities in implementing intelligent manufacturing systems in real-world industrial settings.

- To enable students to critically analyze and evaluate the impact of intelligent manufacturing on productivity, quality, and sustainability.
- To equip students with the knowledge and skills necessary to design, develop, and deploy intelligent manufacturing solutions.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Analyze real-world manufacturing scenarios and identify opportunities for intelligent system integration.	L2
C02	Design and implement intelligent manufacturing solutions using AI, IoT, and robotics technologies.	L2
C03	Evaluate the impact of intelligent manufacturing on productivity, quality, and sustainability in industrial contexts.	L3
C04	Collaborate effectively in teams to solve complex manufacturing problems using intelligent technologies.	L3
C05	Analyze and optimize robot programs for improved performance.	L3

COURSE CONTENT:	
Module 1: Introduction to Intelligent Manufacturing Systems	08Hrs
Overview of intelligent manufacturing systems and their role in Industry 4.0. Historical development and evolution of manufacturing technologies. Key components and technologies in intelligent manufacturing (AI, IoT, Cyber-Physical Systems, etc.). Applications and benefits of intelligent manufacturing in different industries.	
Module 2: Smart Sensors and Data Acquisition	08Hrs
Understanding the role of sensors and data acquisition in intelligent manufacturing. Types of sensors used in manufacturing processes and their working principles. Data processing, fusion, and interpretation for decision-making. Real-time monitoring and control of manufacturing processes using sensor data.	
Module 3: Artificial Intelligence in Manufacturing	08Hrs
Introduction to Artificial Intelligence (AI) and its relevance in manufacturing. Machine learning algorithms for predictive maintenance, quality control, and optimization. Robotics and automation in intelligent manufacturing systems. Case studies of AI-driven manufacturing applications.	
Module 4: Internet of Things (IoT) in Manufacturing	07Hrs
Fundamentals of the Internet of Things and its integration with manufacturing systems. Industrial IoT protocols and communication standards. IoT-enabled	

supply chain management and inventory control. Security and privacy considerations in IoT-enabled manufacturing.	
Module 5: Implementing and Managing Intelligent Manufacturing Systems	08Hrs
Design considerations for intelligent manufacturing systems. Integration of intelligent manufacturing technologies with legacy systems. Challenges, risks, and mitigations in adopting intelligent manufacturing. Lifecycle management and continuous improvement of intelligent manufacturing systems.	

TEXT BOOKS:

1. "Intelligent Manufacturing Systems", Andrew Kusiak, Edition: 2nd, Publisher: Prentice Hall Publication, 2001.
2. "Intelligent Manufacturing: Multi-Agent Systems and Virtual Environments", Lihui Wang, Andrew Kusiak, Edition: 4th, Springer, 2009

REFERENCES:

1. "Intelligent Manufacturing: Reviving U.S. Manufacturing Including Lessons Learned from Delphi Packard Electric and General Motors", Jay Lee, Helu Miao, Edition: 1st, LAP Lambert Academic Publishing, 2010

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4714					
TITLE OF THE COURSE	Powder Metallurgy Manufacturing					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

- Understand the principles and fundamentals of powder metallurgy as a manufacturing process.
- Identify the different powder metallurgy techniques and their applications in various industries.
- Gain knowledge of the properties and characteristics of powder materials used in

manufacturing processes.

- Analyze the advantages and limitations of powder metallurgy compared to conventional manufacturing methods.
- Develop the skills necessary to design, produce, and assess powder metallurgy components.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply powder metallurgy principles to develop manufacturing solutions for specific industrial applications.	L2
CO2	Design and optimize powder metallurgy processes for enhanced component performance.	L2
CO3	Evaluate the properties and characteristics of powder materials to select appropriate materials for manufacturing.	L3
CO4	Assess the advantages and limitations of powder metallurgy in comparison to traditional manufacturing methods.	L3
CO5	Demonstrate proficiency in fabricating powder metallurgy components and conducting quality control tests.	L3

COURSE CONTENT:	
Module 1: Introduction to Powder Metallurgy	08Hrs
Overview of powder metallurgy and its historical development. Fundamentals of powder metallurgy processes. Powder characteristics and properties. Powder production methods.	
Module 2: Powder Compaction and Shaping	08Hrs
Principles of powder compaction. Types of compaction presses and their operation. Tooling design for powder compaction. Post-compaction shaping techniques.	
Module 3: Sintering and Heat Treatment	08Hrs
Fundamentals of sintering and its mechanisms. Sintering furnaces and atmosphere control. Sintering kinetics and densification. Heat treatment of powder metallurgy components.	
Module 4: Secondary Operations in Powder Metallurgy	07Hrs
Debinding techniques for removing binders from green compacts. Post-sintering treatments (e.g., impregnation, infiltration, etc.). Finishing operations for powder metallurgy components.	
Module 5: Powder Metallurgy Applications and Advanced Techniques	08 Hrs
Automotive applications of powder metallurgy components. Aerospace and defense industry applications. Powder metallurgy in biomedical and consumer goods. Metal injection molding (MIM) and its advantages. Powder forging and its application in producing high-strength components. Powder spraying and	

coating techniques.	

TEXT BOOKS:

1. Powder Metallurgy Science, Randall M. German, Edition: 4th, Metal Powder Industries Federation (MPIF), 2017
2. Powder Metallurgy: Principles and Applications", Brian Cantor, F. C. Campbell, Patrick Grant, Edition: 1st, Cambridge University Press, 2014

REFERENCES:

3. Advances in Powder Metallurgy: Properties, Processing, and Applications", Editor: Isaac Chang, Yuyuan Zhao, Mingzhi Chen, Woodhead Publishing, 2013

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4715					
Course Name	Powertrain Integration in Hybrid Electric Vehicles (HEV)					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To provide students with a comprehensive understanding of the powertrain integration in Hybrid Electric Vehicles (HEVs).
- Explain different classifications of HEVs and the principles of energy management strategies.

- Familiarize students with the key components of HEV powertrains and their functions.
- To equip students with the knowledge and skills necessary to design, analyze, and optimize powertrain systems in HEVs, considering factors such as energy efficiency, performance, and environmental impact.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the fundamentals of hybrid electric vehicle powertrains and their key components.	L2
CO2	Analyze the interactions between different powertrain components in HEVs.	L2
CO3	Design and optimize powertrain systems to achieve desired performance and efficiency in HEVs.	L3
CO4	Evaluate the environmental impact and benefits of integrating specific powertrain technologies in HEVs.	L3
CO5	Apply theoretical knowledge to practical scenarios and problem-solving related to powertrain integration in HEVs.	L3

COURSE CONTENT:	
Module 1: Introduction to Hybrid Electric Vehicles	
Introduction to HEVs and their advantages, Classification of HEVs: Series, Parallel, Series-Parallel, Energy management strategies in HEVs, Regenerative braking and energy recovery	08Hrs
Module 2: Powertrain Components in HEVs	08Hrs
Internal combustion engines (ICEs) in HEVs Electric motors and generators High voltage batteries and energy storage systems Power electronics and inverters	
Module 3: Powertrain Integration and Control	08Hrs
Powertrain control strategies and architectures, Powertrain modeling and simulation techniques, Energy flow analysis in HEVs, Control algorithms for optimal power distribution	
Module 4: Powertrain Efficiency and Optimization	07Hrs
Efficiency analysis of powertrain components, Powertrain optimization for performance and fuel economy, Advanced powertrain technologies: Plug-in Hybrid Systems (PHEVs), Range Extenders, etc. Design considerations for powertrain integration	
Module 5: Environmental Impact and Future Trends	08Hrs
Environmental impact assessment of HEVs, Life cycle analysis and carbon footprint, Emerging trends and future developments in powertrain integration Sustainable transportation and the role of HEVs in the future	

TEXT BOOKS:

1. Hybrid Electric Vehicle Design and Control: Intelligent Omnidirectional Hybrids" by Simona Onori, Lorenzo Serrao, and Giorgio Rizzoni
2. Advanced Electric Drive Vehicles" by Ali Emadi
3. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design" by Mehrdad Ehsani, Yimin Gao, and Ali Emadi

REFERENCES:

1. Hybrid Electric Vehicle Technology" by H. Johannes Helmut and Qiyan Wu
2. Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4716					
Course Name	ENERGY MANAGEMENT AND CONTROL STRATEGIES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To provide students with a solid understanding of energy management principles and their importance in sustainable development.
- To familiarize students with various energy control strategies and technologies used to

- enhance energy efficiency and conservation.
- To develop students' abilities to analyze energy consumption patterns, identify areas of improvement, and recommend energy-saving measures.
- To enable students to assess the economic and environmental implications of different energy management strategies.
- To prepare students to design and implement energy management plans that meet the specific needs and requirements of different industries.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Evaluate energy consumption patterns and identify opportunities for energy conservation in industrial and commercial facilities.	L2
CO2	Implement and apply advanced energy control strategies, such as demand response, load shedding, and peak shaving, to optimize energy consumption.	L2
CO3	Analyze the economic feasibility of energy management projects, considering factors such as payback period, return on investment, and cost-benefit analysis.	L3
CO4	Formulate comprehensive energy management plans tailored to the unique requirements and constraints of different organizations.	L3
CO5	Demonstrate a thorough understanding of environmental implications related to energy usage and propose strategies to reduce carbon footprint and greenhouse gas emissions.	L3

COURSE CONTENT:	
Module 1: Introduction to Energy Management	
Energy management fundamentals, Global energy scenario and sustainability Energy auditing and performance assessment, Energy efficiency standards and regulations	08Hrs
Module 2: Energy Control Strategies and Technologies	
Load management and peak demand reduction, Building automation systems and smart controls, Energy storage systems and integration, Renewable energy integration and microgrids	08Hrs
Module 3: Economic and Financial Aspects of Energy Management	
Cost-benefit analysis and life-cycle costing, Energy pricing and tariff structures Financing energy management projects, Incentives and subsidies for energy conservation	08Hrs
Module 4: Environmental Impact and Green Initiatives	
Environmental aspects of energy consumption, Carbon footprint assessment and reduction strategies, Energy-efficient building design and LEED certification, Corporate social responsibility and sustainable practices	07Hrs

Module 5: Energy Management Plan Development and Implementation	08Hrs
Energy data analytics and management software, Developing customized energy management plans, Stakeholder engagement and change management Monitoring, evaluation, and continuous improvement	

TEXT BOOKS:

1. Energy Management Principles: Applications, Benefits, Savings" by Craig B. Smith and Kelly E. Parmenter
2. Energy Management Handbook" by Wayne C. Turner and Steve Doty
3. Industrial Energy Management: Principles and Applications" by Alaa El-Sayed Abdel-Aal

REFERENCES:

1. Energy Efficiency: Principles and Practices" by Ibrahim Dincer and Marc A. Rosen
2. Handbook of Energy Audits" by Albert Thumann and William J. Younger
3. Energy Economics: Concepts, Issues, Markets, and Governance" by Subhes C. Bhattacharyya

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4717					
TITLE OF THE COURSE	AUTOMOBILE ENGINEERING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course
1	-	-	-

COURSE OBJECTIVES :

- To understand basics of Automobile Engineering & various automotive system.
- To understand vehicle layout, vehicle specifications & important of automobile.
- To make the student conversant with drive train & transmission.
- Understand the various Automobile Electrical System, Vehicle performance & theirsafety

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Analyze Development and Role of Automobile Engineering.	L3
CO2	Evaluate Clutches, Gearboxes, and Drive Systems.	L3
CO3	Design Axles, Steering, Suspension, and Brake Systems.	L3
CO4	Analyze Vehicle Performance and Safety Parameters.	L3
CO5	Implement Understanding of Vehicle Battery and Accessory Systems.	L4
CO6	Perform Vehicle Maintenance and Servicing.	L3

MODULE 1	08Hrs
Automobile history and development, current scenario in Indian auto/ ancillary industries, Role of the automobile industry in national growth, Classification, types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames. Constructional details, Unitised frame body construction, Loads acting on vehicle frame, details of chassis material.	
MODULE 2	08Hrs
Classification of clutches, Single plate & with dual flywheel effect, Multi plate, Cone, diaphragm spring, Centrifugal, Clutch materials, Clutch plate, Electromagnetic, vacuum operated, Necessity of gear box, Manual gear box-Constant mesh, Sliding mesh, Synchromesh, Epicyclic, fluid flywheel, Torque convertor, Continuous variable transmission, Electronic transmission control, overdrive, Propeller Shaft, Universal Joint, Differential and final drive, hotchkiss drive, torque tube drive.	
MODULE 3	08Hrs
Axle: Purpose and requirement of front & rear axle, live and dead axles types & arrangement, types of loads acting on rear axles, full floating, three quarter floating and semi floating rear axles. Steering System: Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristic, steering linkages & gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering. Suspension: Sprung and unsprung mass, types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), damping and shock absorbers Brakes: Types of brake systems - drum, disc, operation-mechanical, hydraulic, air brakes, servo and power braking, hand brake, ABS.	
MODULE 4	07Hrs

Vehicle performance parameters, road resistance, traction and tractive effort, power requirement for propulsion, road performance curves(Numerical treatment expected), Stability of vehicles, roll over safety regulations, Vehicle safety- active, passive safety, air bags, seat belt, Vehicle interior and ergonomics, comfort, NVH in automobiles, electrical car layout, hybrid vehicles, Solar operated vehicle, measuring instruments for wear, speed, acceleration, vibration, noise.	
MODULE 5	08Hrs
Batteries: Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods. Lighting System & Accessories: Insulated & earth return systems, positive & negative earth systems, electrical fuel pump, speedometer, fuel, oil & temperature gauges, horn, wiper system, trafficator, sensors and actuators, electronic control unit, traction control devices. Vehicle maintenance Schedule maintenance chart of a vehicle, maintenance, overhauling & servicing of chassis, clutch, gear box, propeller shaft, differential, axles, steering system, wheels, tyres, suspension, brakes system, electrical system.	

TEXT BOOKS :

1. William H. Crouse, "Automotive Mechanics", Tata McGraw Hill Publishing House.

REFERENCES :

3. K. Newton and W. Seeds, T.K. Garrett, "Motor Vehicle", 13th Edition, Elsevier publications
4. Hans Hermann Braess, Ulrich Seiffen, "Handbook of Automotive Engineering", SAE Publications

SEMESTER	VII					
YEAR	IV					
COURSE CODE	20ME4718					
Course Name	TRIBOLOGY AND BEARING DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To introduce students to the fundamentals of tribology, including the study of friction, wear, and lubrication mechanisms.

- To provide an in-depth understanding of bearing types, their principles of operation, and their applications in mechanical systems.
- To familiarize students with the design considerations and selection criteria for bearings in different engineering scenarios.
- To enable students to analyze and evaluate tribological performance, predict wear rates, and optimize bearing design.
- To prepare students to apply their knowledge to solve real-world tribology and bearing challenges in engineering practice.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the principles of tribology and the significance of friction, wear, and lubrication in mechanical systems.	L2
CO2	Describe the different types of bearings, their construction, and their applications in various engineering fields.	L2
CO3	Analyze and evaluate the performance of bearings under different loading conditions and operating environments.	L3
CO4	Design and select appropriate bearings for specific engineering applications based on performance requirements and constraints.	L3
CO5	Apply tribological concepts and knowledge to address practical problems related to friction, wear, and bearing design.	L3

COURSE CONTENT:	
Module 1: Introduction to Tribology	
Definition and scope of tribology, Friction and its classification, Wear mechanisms and types, Lubrication regimes and lubricants	08Hrs
Module 2: Principles of Bearing Design	
Types of bearings: rolling, sliding, and fluid film bearings, Bearing materials and properties, Load capacity and bearing life calculations, Bearing standards and specifications	08Hrs
Module 3: Bearing Applications and Selection	
Bearing arrangements in mechanical systems, Bearing failure analysis and troubleshooting, Specialty bearings and advanced applications, Bearing selection based on load, speed, and environment	08Hrs
Module 4: Lubrication in Bearings	
Lubrication theory and principles, Lubricant types and properties, Lubrication systems and methods, Lubricant testing and condition monitoring	07Hrs
Module 5: Advanced Topics in Tribology and Bearing Design	
	08Hrs

Surface engineering and coatings for enhanced tribological performance, Bearing dynamics and vibration analysis, Green tribology and sustainable bearing design, Case studies and industry best practices	

TEXT BOOKS:

1. Tribology and Bearing Design" by Michael M. Khonsari and E. Richard Booser
2. "Principles and Applications of Tribology" by Bharat Bhushan
3. "Bearing Design in Machinery: Engineering Tribology and Lubrication" by Avraham Harnoy

REFERENCES:

1. Tribology: Friction and Wear of Engineering Materials" by Ian Hutchings
2. "Lubrication Fundamentals" by Don M. Pirro and Robert W. Bruce
3. "Bearing Design and Fitting" by A. J. Esdaile and H. A. Rothberg

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4802					
Course Name	ADVANCED AI FOR ROBOTICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To inculcate deep understanding of advanced AI techniques in the context of robotics.

- To enable students to implement and design AI models for specific robotic applications.
- To provide hands-on experience with current AI tools and frameworks relevant to robotics.
- To foster critical thinking and analysis of AI applications in robotics, considering strengths, weaknesses, and societal implications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply Machine Learning Techniques to Robotic Systems.	L3
CO2	Utilize Computer Vision in Robotics.	L2
CO3	Implement AI-Based Decision Making and Control.	L4
CO4	Analyze and Evaluate AI Techniques in Robotics.	L3
CO5	Design AI Models for Specific Robotic Applications.	L3
CO6	Apply Advanced AI Concepts in Robotics.	L3

COURSE CONTENT:	
Module 1	
Introduction to Advanced AI for Robotics Topics include: Review of basic AI concepts, Introduction to AI for robotics, Role and application of AI in Robotics, Brief overview of robotic systems, Different types of robots and their AI requirements.	08Hrs
Module 2	
Machine Learning for Robotics Topics include: Supervised, Unsupervised, and Reinforcement learning in robotics context, Deep learning techniques for perception, Prediction modeling for robotic control, Robot learning from demonstration, Hands-on lab sessions with Machine Learning frameworks.	
Module 3	
Perception and Vision for Robotics Topics include: Computer Vision techniques for robotics, Object detection and recognition, Semantic segmentation and scene understanding, Depth perception and 3D vision, Multimodal sensor fusion for enhanced perception.	08Hrs

Module 4	07Hrs
AI-based Decision Making and Control Topics include: Path planning and navigation, Decision making under uncertainty, Reinforcement learning for control policy generation, Multi-robot systems and collaborative AI, Evolutionary algorithms for optimization in robotics.	
Module 5	08Hrs
Advanced Topics and Future Directions Topics include: Ethics and societal implications of AI in robotics, Case studies of AI applications in modern robotic systems, Emerging trends in AI for robotics - Explainable AI, AI for Human-Robot Interaction, Challenges and opportunities in the field.	

Textbooks:

- "Probabilistic Robotics" by Sebastian Thrun, Wolfram Burgard, and Dieter Fox, MIT Press, 2005.
- "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig, Pearson, 3rd Edition, 2009.

References:

- "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016.
- "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto, MIT Press, 2nd Edition, 2018.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4803					
Course Name	ROBOT SIMULATION & OFFLINE PROGRAMMING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To introduce students to the principles and techniques of robot simulation and offline

programming.

- To provide hands-on experience with software tools used in robot simulation and offline programming.
- To enable students to develop, test, and implement offline robot programs.
- To explore the integration of AI and machine learning in robot simulation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Implement Fundamentals of Robot Simulation.	L4
CO2	Apply Principles of Offline Robot Programming.	L3
CO3	Analyze Practical Applications of Robot Simulation.	L3
CO4	Develop Offline Robot Programs.	L3
CO5	Utilize Software Tools for Simulation and Offline Programming.	L3
CO6	Incorporate AI and Machine Learning in Robot Simulation.	L3

COURSE CONTENT:	
Module 1	
Introduction to Robot Simulation and Offline Programming Topics: Overview of robot simulation, Introduction to offline programming, Benefits and challenges of simulation and offline programming, General robotics and programming review.	08Hrs
Module 2	
Fundamentals of Robot Simulation Topics: Essential elements of robot simulation, Working with robot models, Interpreting robot kinematics and dynamics, Creating virtual environments, Simulation of robot sensors and perception systems.	08Hrs
Module 3	
Principles of Offline Robot Programming Topics: Overview of robot programming languages, Developing offline robot programs, Testing and debugging of robot programs, Integrating robot programs into simulated environments, Safe robot operation through offline programming.	08Hrs
Module 4	
	07Hrs

Practical Applications of Robot Simulation and Offline Programming Topics: Case studies in manufacturing, healthcare, autonomous robots, and other sectors, Performance analysis and optimization using simulation, Human-robot interaction simulation, Collision detection and avoidance in simulation, Real-world implementation of offline programs.	
Module 5	08Hrs
Advanced Topics and Software Tools in Robot Simulation and Offline Programming Topics: Emerging trends in simulation and offline programming, Overview of software tools for robot simulation (such as ROS, Gazebo, V-REP, RoboDK), Offline programming software (such as RobotStudio, Roboguide), Integration of AI and Machine Learning in robot simulation, Future directions in simulation and offline programming.	

Textbooks:

- "Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, Wiley, 1st Edition, 2005.
- "Introduction to Robotics: Analysis, Control, Applications" by Saeed B. Niku, Wiley, 2nd Edition, 2010.

References:

- "Robotics, Vision and Control: Fundamental Algorithms in MATLAB" by Peter Corke, Springer, 2nd Edition, 2017.
- "Robot Programming: A Guide to Controlling Autonomous Robots" by Cameron Hughes and Tracey Hughes, Que Publishing, 1st Edition, 2016.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4804					
Course Name	ADDITIVE MANUFACTURING FOR MEDICAL APPLICATIONS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To understand the basic principles and technologies in additive manufacturing for

medical applications.

- To familiarize with the various biocompatible materials used in medical additive manufacturing.
- To learn the different AM techniques and their application in the medical field.
- To develop the ability to design and optimize CAD models for medical additive manufacturing.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply Principles of Additive Manufacturing.	L3
CO2	Select Biocompatible Materials.	L3
CO3	Implement AM Techniques in Medical Applications.	L4
CO4	Design Models for Medical AM.	L3
CO5	Follow Regulatory Guidelines.	L3
CO6	Analyze Applications of Medical AM.	L3

COURSE CONTENT:	
Module 1	
Introduction to Additive Manufacturing and Medical Applications Topics: Overview of additive manufacturing (AM), History and evolution of AM in medical field, AM technologies used in medical applications, Benefits and challenges of using AM in medical industry.	08Hrs
Module 2	
Biocompatible Materials for Additive Manufacturing Topics: Understanding biocompatible materials, Materials used in AM for medical applications (polymers, metals, ceramics, and biocomposites), Properties and selection of biocompatible materials, Case studies of material use in medical AM.	08Hrs
Module 3	
Additive Manufacturing Techniques in Medical Applications Topics: Overview of AM techniques used in medical applications such as Stereolithography (SLA), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), Direct Metal Laser Sintering (DMLS), and Bioprinting, Case	08Hrs

studies on the use of these techniques in creating medical devices, implants, and more.	
Module 4	07Hrs
Design and Modeling for Medical Additive Manufacturing Topics: Introduction to design principles for AM, Design considerations for medical applications, Computer-Aided Design (CAD) for AM, Generating and optimizing models for medical AM, Regulatory considerations in the design of AM medical devices.	
Module 5	08Hrs
Applications and Future Directions of Medical Additive Manufacturing Topics: Detailed examination of AM applications in medical field including custom implants, prosthetics, tissue engineering, and pharmaceuticals, Challenges and solutions in medical AM, Ethical considerations, Emerging trends and future directions in AM for medical applications.	

Textbooks:

- "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing" by Ian Gibson, David Rosen, Brent Stucker, Springer, 2nd Edition, 2014.
- "3D Printing in Medicine" by Frank J. Rybicki, Gerald T. Grant, Springer, 1st Edition, 2017.

References:

- "3D Printing of Medical Devices and Tissue Engineering Structures" by Murat Guvendiren, Springer, 1st Edition, 2020.
- "3D Printing Applications in Cardiovascular Medicine" by James K Min, Subhi J Al'Aref, Reza Ardehali, Dudley S Childress, Academic Press, 1st Edition, 2018.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4805					
Course Name	SUSTAINABLE MANUFACTURING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To understand the concept of sustainable manufacturing and its importance.
- To learn how to conduct a life cycle assessment (LCA) for manufacturing processes and products.
- To gain knowledge on how to implement energy efficiency measures in manufacturing.
- To develop skills for managing and reducing waste in the manufacturing process.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Assess Impact of Manufacturing Practices.	L3
CO2	Apply Life Cycle Assessment.	L3
CO3	Implement Energy Efficiency Measures.	L4
CO4	Manage and Reduce Waste.	L3
CO5	Incorporate Sustainable Practices in Supply Chain.	L3
CO6	Evaluate Sustainable Manufacturing Systems.	L3

COURSE CONTENT:	
Module 1	
Introduction to Sustainable Manufacturing Topics: Definition and principles of sustainable manufacturing, Role and importance of sustainable manufacturing, Challenges and benefits, Overview of the sustainable manufacturing process, Impact of manufacturing on the environment.	08Hrs
Module 2	
Life Cycle Assessment in Manufacturing Topics: Basics of life cycle assessment (LCA), Phases of LCA - Goal and Scope Definition, Inventory Analysis, Impact Assessment, Interpretation, Case studies of LCA application in manufacturing.	08Hrs
Module 3	
Energy Efficiency in Manufacturing Topics: Importance of energy efficiency in manufacturing, Energy management, Energy audit, Techniques to improve energy efficiency, Case studies on energy efficient manufacturing systems.	08Hrs

Module 4	07Hrs
Waste Management and Reduction in Manufacturing Topics: Manufacturing waste types, Impact of waste on environment, Techniques for waste reduction and management, Recycling and reuse in manufacturing, Case studies on waste management in manufacturing industries.	
Module 5	08Hrs
Sustainable Supply Chain and Green Manufacturing Topics: Introduction to sustainable supply chain, Green manufacturing practices, Role of lean and green manufacturing in sustainability, Case studies on implementation of sustainable supply chain and green manufacturing, Future trends in sustainable manufacturing.	

Textbooks:

- "Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives" by Rainer Stark, Günther Seliger, Jérémy Bonvoisin, Springer, 1st Edition, 2017.
- "Green and Lean Management" by Cinzia Battistella, Fabio Nonino, Springer, 1st Edition, 2016.

References:

- "Industrial Ecology and Sustainable Engineering" by T. E. Graedel, B. R. Allenby, Prentice Hall, 1st Edition, 2010.
- "Green Manufacturing: Fundamentals and Applications" by David A. Dornfeld, Springer, 1st Edition, 2013.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4806					
Course Name	ADVANCED PROPULSION SYSTEMS FOR HYBRID ELECTRIC DRIVE VEHICLES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To familiarize students with the concepts and technologies associated with Hybrid Electric Drive Vehicles (HEDVs).
- To develop proficiency in working with electric propulsion systems used in HEDVs.
- To understand how to integrate Internal Combustion Engine (ICE) propulsion systems within hybrid vehicle frameworks.
- To gain practical knowledge of implementing various energy storage systems and managing their usage in HEDVs.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply Knowledge of HEDVs.	L3
CO2	Use Electric Propulsion Systems.	L3
CO3	Integrate ICE in Hybrid Systems.	L3
CO4	Implement Energy Storage Systems.	L4
CO5	Employ Hybrid Energy Management Techniques.	L3
CO6	Evaluate HEDV Performance.	L3

COURSE CONTENT:	
Module 1	
Introduction to Hybrid Electric Drive Vehicles Topics: Overview of Hybrid Electric Drive Vehicles (HEDVs), Types of HEDVs - Mild Hybrid, Full Hybrid, Plug-In Hybrid, History and evolution of HEDVs, Benefits and challenges of HEDVs, Introduction to propulsion systems.	08Hrs
Module 2	
Electric Propulsion Systems Topics: Overview of electric propulsion, Electric machines - Permanent Magnet Synchronous Machines (PMSMs), Induction Machines (IMs), Switched Reluctance Machines (SRMs), Electric propulsion drive configurations, Motor control techniques.	08Hrs
Module 3	
	08Hrs

Internal Combustion Engine (ICE) Propulsion Systems Topics: Principles of operation of ICE, Types of ICE - petrol, diesel, Gasoline Direct Injection (GDI), Engine control unit (ECU), ICE for hybrid applications, Downsizing and supercharging.	
Module 4	07Hrs
Energy Storage Systems Topics: Overview of energy storage technologies, Batteries - Lithium-ion, Nickel-Metal Hydride (NiMH), Lead-acid, Ultracapacitors, Fuel cells, Battery management systems.	
Module 5	08Hrs
Hybrid Energy Management and Control Topics: Hybrid energy management principles, Control strategies - Rule-based control, Optimized control, Predictive control, Evaluation of energy management strategies, Hybrid vehicle simulation and modeling.	

Textbooks:

- "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design" by Mehrdad Ehsani, Yimin Gao, Stefano Longo, CRC Press, 2nd Edition, 2018.
- "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives" by Chris Mi, M. Abul Masrur, David Wenzhong Gao, Wiley, 2nd Edition, 2017.

References:

- "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain, CRC Press, 2nd Edition, 2011.
- "Electric Vehicle Technology Explained" by James Larminie, John Lowry, Wiley, 2nd Edition, 2012.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4807					
Course Name	AUTOMOTIVE ELECTRONICS FOR EV'S					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To understand the fundamentals of Automotive Electronics in the context of Electric Vehicles.
- To study the principles and applications of power electronics in EVs.
- To explore the design and functioning of Battery Management Systems, Control Systems, and Telematics in EVs.
- To evaluate the performance of EVs and keep updated with recent technological advancements in the field.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Design EV Architecture.	L3
CO2	Apply Power Electronics in EV context.	L3
CO3	Implement Battery Management Systems.	L4
CO4	Employ Control Systems in EVs.	L3
CO5	Develop Telematics and Infotainment Systems.	L3
CO6	Evaluate EV Performance.	L3

COURSE CONTENT:	
Module 1	
Introduction to Electric Vehicles (EVs) and Automotive Electronics Topics: History and evolution of EVs, Overview of Automotive Electronics, Role of electronics in EVs, Different types of EVs - BEVs, HEVs, PHEVs, FCEVs.	08Hrs
Module 2	
EV Architecture and Power Electronics Topics: Overview of EV architecture, Powertrain components, Role of power electronics in EVs, Power electronic converters (DC-DC, DC-AC, AC-DC), Motor drives.	08Hrs
Module 3	
	08Hrs

Battery Management Systems (BMS) Topics: Role of BMS in EVs, Battery technology for EVs, State of Charge (SoC) and State of Health (SoH) estimation methods, Battery safety and thermal management, Charging and discharging strategies.	
Module 4	07Hrs
EV Control Systems Topics: Introduction to control systems in EVs, Traction control, Braking control, Energy management control strategies, Stability control, Autonomous driving features in EVs.	
Module 5	08Hrs
Telematics and Infotainment Systems Topics: Overview of telematics and infotainment systems, Communication protocols used in EVs, Vehicle to Grid (V2G), Vehicle to Vehicle (V2V), and Vehicle to Infrastructure (V2I) communication, Over-the-air updates, Cybersecurity for EVs.	

Textbooks:

- "Electric Vehicle Technology Explained" by James Larminie and John Lowry, Wiley, 2nd Edition.
- "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design" by Mehrdad Ehsani, Yimin Gao, and Ali Emadi, CRC Press, 2nd Edition.

References:

- "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain, CRC Press, 2nd Edition.
- "Vehicle Power Management: Modeling, Control and Optimization" by Xu Li, Springer, 1st Edition.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4808					
Course Name	FEM- STRUCTURAL MECHANICS APPLICATIONS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- Understand the fundamentals and principles of Finite Element Method in the context of structural mechanics.
- Apply Finite Element Method for solving various structural mechanics problems.
- Develop the ability to model and analyze different types of structural elements and systems.
- Explore advanced applications of Finite Element Method in structural mechanics, including non-linear analysis and fracture mechanics.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Implement FEM in 1D Problems.	L3
CO2	Apply FEM to 2D Problems.	L3
CO3	Solve 3D Structural Problems.	L4
CO4	Analyze Plate and Shell Structures.	L3
CO5	Perform Non-linear Analysis.	L4
CO6	Conduct Fracture and Fatigue Analysis.	L3

COURSE CONTENT:	
Module 1	
Introduction to Finite Element Method (FEM) Topics: History and evolution of FEM, Review of structural mechanics, Overview of FEM in structural mechanics, Discretization, interpolation functions and shape functions, Principle of minimum potential energy.	08Hrs
Module 2	
One-dimensional Problems Topics: Introduction to 1D problems, FEM formulation for axial load deformation problems, FEM formulation for thermal problems, Implementation and solution of 1D problems, Effect of boundary conditions and loadings, Comparison with analytical solutions.	

Module 3	08Hrs
Two-dimensional Problems Topics: Introduction to 2D problems, FEM formulation for plane stress, plane strain and axisymmetric problems, Triangular and quadrilateral elements, Meshing strategies, Implementation and solution of 2D problems, Dealing with complex geometries.	
Module 4	07Hrs
Three-dimensional Problems Topics: Introduction to 3D problems, FEM formulation for 3D elasticity problems, Tetrahedral and hexahedral elements, Meshing strategies, Implementation and solution of 3D problems, Dealing with large deformations and non-linearity.	
Module 5	08Hrs
Advanced Topics in FEM for Structural Mechanics Topics: FEM for plate and shell problems, Introduction to buckling and post-buckling analysis using FEM, Non-linear analysis in FEM, FEM for fracture mechanics and fatigue problems, Introduction to software tools for FEM analysis.	

Textbooks:

- "A First Course in the Finite Element Method", Daryl L. Logan, Cengage Learning; 6th edition.
- "The Finite Element Method: Linear Static and Dynamic Finite Element Analysis", Thomas J.R. Hughes, Dover Publications; 1st edition.

References:

- "Finite Element Procedures", Klaus-Jurgen Bathe, Prentice Hall; 2nd edition.
- "The Finite Element Method in Engineering", Singiresu S. Rao, Butterworth-Heinemann; 6th edition.

SEMESTER	VIII					
YEAR	IV					
COURSE CODE	20ME4809					
Course Name	ORGANIZATIONAL BEHAVIOUR AND PROFESSIONAL COMMUNICATION					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	39	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objective of this course is

- To provide a comprehensive understanding of Organizational Behaviour.
- To enhance leadership and decision-making skills.
- To improve professional communication skills for business environments.
- To foster ethical sensitivity and corporate social responsibility.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply concepts of organizational behaviour to real-life business situations.	L3
CO2	Formulate strategies for effective group dynamics and team development.	L3
CO3	Implement appropriate leadership styles and decision-making techniques.	L4
CO4	Demonstrate proficiency in professional communication, both written and oral.	L3
CO5	Apply problem-solving and negotiation skills in a variety of organizational contexts.	L4
CO6	Design and implement CSR strategies in alignment with organizational objectives.	L3

COURSE CONTENT:	
Module 1	
Introduction to Organizational Behaviour The nature and significance of Organizational Behaviour. Understanding the relationship between an individual and an organization. Introduction to individual behavior, personality, perception, and attribution.	08Hrs
Module 2	
Group Behaviour and Team Development Concepts of group dynamics and team development. Analysis of roles, norms, conformity, status, and cohesiveness in a group. Techniques for effective team building. Study of conflict management and negotiation skills.	08Hrs
Module 3	
	08Hrs

Leadership and Decision Making Concepts of leadership and the role of a leader. Understanding different leadership styles. Principles of effective decision making. Techniques for problem-solving and decision-making in an organizational context.	
Module 4	07Hrs
Professional Communication Importance of communication in an organization. Barriers to effective communication and ways to overcome them. Study of written, oral, and non-verbal communication. Importance of listening skills and feedback in communication.	
Module 5	08Hrs
Ethics and Corporate Social Responsibility Concepts of professional ethics and ethical dilemmas in organizations. Study of Corporate Social Responsibility (CSR) and its impact on organizational performance. Understanding the influence of culture and diversity in organizational behavior.	

Textbooks:

- "Organizational Behavior", Stephen P. Robbins, Timothy A. Judge, Pearson; 18th edition.
- "Essentials of Business Communication", Mary Ellen Guffey, Dana Loewy, Cengage Learning; 11th edition.

References:

- "Understanding Organizational Behavior", Udai Pareek, Oxford University Press; 3rd edition.
- "Effective Business Communication", Herta A Murphy, Herbert W Hildebrandt, Jane P. Thomas, McGraw Hill Education; 7th edition.

DAYANANDA SAGAR UNIVERSITY

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SCHOOL OF ENGINEERING

SCHEME & SYLLABUS FOR MASTER OF TECHNOLOGY (M.Tech) – 2022

MECHANICAL ENGINEERING

SPECIALIZATION: DESIGN ENGINEERING

(With Effect from 2022-23)

SEMESTER I

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	$\frac{CR}{AU}$	SCHEME OF TEACHING				
					L	T	P	S/P	C
1	204	22MDE5101	EXPERIMENTAL STRESS ANALYSIS	CR	03	01	-	-	04
2	204	22MDE5102	FINITE ELEMENT METHOD	CR	03	--	02	-	04
3	204	22MDE5103	SOLID MECHANICS	CR	03	--	02	-	04
4	204	22MDE5XXX	DEPARTMENT ELECTIVE-I	CR	03	-	-	-	03
5	204	22MDE5XXX	DEPARTMENT ELECTIVE-II	CR	03	-	-	-	03
6	204	22MDE5104	SPECIAL TOPICS	CR	-	02	-	-	02
GRAND TOTAL = 600					15	03	04	-	20

SEMESTER II

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	$\frac{CR}{AU}$	SCHEME OF TEACHING				
					L	T	P	S/P	C
1	204	22MDE5201	ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGY	CR	03	--	04	-	05
2	204	22MDE5202	MECHANICS OF COMPOSITE MATERIALS	CR	03	01	-	-	04
3	204	22MDE5203	ADVANCED MACHINE DESIGN	CR	03	--	04	-	05
4	204	22MDE5XXX	DEPARTMENT ELECTIVE-III	CR	03	01	-	-	04
5	204	22MDE5XXX	DEPARTMENT ELECTIVE-IV	CR	03	01	-	-	04
6	204	22MDE5204	MOOC Course	CR	-	03	-	-	03
GRAND TOTAL = 600					15	06	08	-	25

CR – CREDIT, AU – AUDIT, L – LECTURE, T – TUTORIAL, P – PRACTICAL, S/P – SEMINAR/PROJECT, C – NO. OF CREDITS,
CIA – CONTINUOUS INTERNAL ASSESSMENT

SEMESTER III

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	$\frac{CR}{AU}$	SCHEME OF TEACHING				
					L	T	P	S/P	C
1	204	22MDE5XXX	DEPARTMENT ELECTIVE – V	CR	03	1	-	-	04
2	204	22MDE5XXX	OPEN ELECTIVE	CR	03	-	-	-	03
3	204	22MDE5301	DISSERTATION PHASE I	CR	-	-	20	-	10
GRAND TOTAL = 300					06	1	20	-	17

SEMESTER IV

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	$\frac{CR}{AU}$	SCHEME OF TEACHING				
					L	T	P	S/P	C
1	204	22MDE5XXX	DEPARTMENT ELECTIVE – VI	CR	03	1	-	-	04
2	204	22MDE5401	DISSERTATION PHASE II	CR	-	-	24	-	12
GRAND TOTAL = 400					03	1	24	-	16

CR – CREDIT, AU – AUDIT, L – LECTURE, T – TUTORIAL, P – PRACTICAL, S/P – SEMINAR/PROJECT, C – NO. OF CREDITS,
CIA – CONTINUOUS INTERNAL ASSESSMENT

DEPARTMENTAL ELECTIVES – I

SL	COURSE CODES	COURSE TITLE
1	22MDE5031	APPLIED MATHEMATICS
2	22MDE5032	DYNAMICS
3	22MDE5033	PRODUCT DEVELOPMENT
4	22MDE5034	DATA VISUALIZATION
5	22MDE5035	DIGITAL CONTROL SYSTEMS

DEPARTMENTAL ELECTIVES – II

SL	COURSE CODES	COURSE TITLE
1	22MDE5036	ROBOTICS
2	22MDE5037	SENSORS AND SIGNAL CONDITIONING
3	22MDE5038	DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS
4	22MDE5039	LEAN MANUFACTURING
5	22MDE5040	SMART MATERIALS AND STRUCTURES

DEPARTMENTAL ELECTIVES –III

SL	COURSE CODES	COURSE TITLE
1	22MDE5041	MECHATRONICS SYSTEM DESIGN
2	22MDE5042	MODELLING AND SIMULATION
3	22MDE5043	MECHANISM DESIGN
4	22MDE5044	INDUSTRIAL DESIGN AND ERGONOMICS
5	22MDE5045	ADDITIVE MANUFACTURING

DEPARTMENTAL ELECTIVES –IV

SL	COURSE CODES	COURSE TITLE
1	22MDE5046	RESEARCH METHODOLOGY
2	22MDE5047	EMBEDDED SYSTEMS
3	22MDE5048	FRACTURE MECHANICS
4	22MDE5049	MICRO ELECTRICAL MECHANICAL SYSTEMS (MEMS)
5	22MDE5050	TRIBOLOGY

DEPARTMENTAL ELECTIVES – V

SL	COURSE CODES	COURSE TITLE
1	22MDE5051	AUTOMOTIVE ELECTRONICS
2	22MDE5052	JIGS AND FIXTURES DESIGN
3	22MDE5053	OPTIMIZATION TECHNIQUES
4	22MDE5054	DESIGN OF EXPERIMENTS
5	22MDE5055	RELIABILITY AND FAILURE ANALYSIS

DEPARTMENTAL ELECTIVES – VI

1	22MDE5056	ROBUST DESIGN
2	22MDE5057	FINITE ELEMENT METHODS FOR STRUCTURAL MECHANICS APPLICATIONS
3	22MDE5058	DESIGN OF MATERIALS HANDLING SYSTEMS
4	22MDE5059	THEORY OF PLASTICITY
5	22MDE5060	NON LINEAR ANALYSIS

OPEN ELECTIVES

SL	COURSE CODE	COURSE TITLE	OFFERING DEPARTMENT
1	22MDE5061	DIGITAL MARKETING	COMPUTER SCIENCE & ENGINEERING
2	22MDE5062	PRODUCT LIFE CYCLE MANAGEMENT	MECHANICAL ENGINEERING
3	22MDE5063	PROJECT MANAGEMENT	ELECTRONICS & COMMUNICATION ENGINEERING

SEMESTER I

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5101					
TITLE OF THE COURSE	EXPERIMENTAL STRESS ANALYSIS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. Introduce the various aspects of ESA as applied to engineering problems.
2. To solve engineering stress related problems using ESA technique.
3. To study the behavior of Photo elastic materials.
4. To introduce the various aspects Stress, strain and deformation calculations using fringes.
5. To learn fabrication and operational skills and applications for different loading conditions of photo elastic material.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Mount strain gages, take measurements and analyze the obtained data	L2
C02	Design strain gage-based transducers for measuring specific loads.	L3
C03	Describe the different methods of photo elasticity for strain measurement viz, stress freezing, and Moirés method.	L3
C04	Undertake experimental investigation to verify predictions by other methods.	L3
C05	Apply the principles and techniques of brittle coating analysis.	L5

C06	Apply the principles and techniques of holographic interferometry.	L5

COURSE CONTENT:	
MODULE 1 Analysis of Experimental Data	08 Hrs
Introduction: Definition of terms, calibration, standards, dimensions and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning. Analysis of different Experimental Data.	
MODULE 2 Data Acquisition and Processing	10 Hrs
Data Acquisition and Processing: General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to- Analog conversion. Basic components (storage and display) of data acquisition systems. Computer program as a substitute for wired logic. Force, Different torque and Strain Measurement	
MODULE 3 Stress Analysis	10 Hrs
Stress Analysis: Two Dimensional Photo elasticity-nature of light,-wave theory of light, optical interference Polariscopes stress optic law effect of stressed model in plane and circular polariscopes, Isoclinics, Iso chromatics fringe order determination -Fringe multiplication techniques Calibration photo elastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling	
MODULE 4 Three Dimensional Photoelasticity	10 Hrs
Three-Dimensional Photo elasticity: Stress freezing method, General slice, Effective stresses, Stresses separation, Shear difference method, Oblique Incidence Method, secondary principal stresses, scattered light photoelasticity, Polariscopes and stress data analyses.	
MODULE 5 Coating Methods and Mini Project	10 Hrs
Coating Methods: a) Photo elastic Coating Method-Birefringence coating techniques, Sensitivity Reinforcing and thickness effects -data reduction-Stress separation techniques, Photo elastic strain gauges. b) Brittle Coatings Method: Brittle coating technique ⁶ e Principles data analysis-coating materials, Coating techniques.	

Text Books:

1. Holman,"Experimental Methods for Engineers"7thEdition, Tata McGraw-Hill Companies, Inc,NewYork, 2007.
2. R.S.Sirohi,H.C.RadhaKrishna,"Mechanicalmeasurements"NewAgeInternationalPvt.Ltd., NewDel hi,2004
3. Experimental Stress Analysis Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw-Hill, 1984.

4. Instrumentation, Measurement And Analysis Nakra Chaudhary, B C Nakra K K Chaudhry, Tata McGraw-Hill Companies, Inc, NewYork, Seventh Edition,2006.

Reference Books:

1. Measurement Systems Application and Design Doeblin E.A., 4th (S.I.) Edition, McGraw Hill, New York. 1989
2. Design and Analysis of Experiments- Montgomery D.C., John Wiley & Sons, 1997.
3. Experimental Stress Analysis- Dally and Riley, McGraw Hill, 1991.
4. Experimental Stress Analysis- Sadhu Singh, Khanna publisher, 1990.
5. Photo elasticity Vallant Vol II- M.M. Frocht, John Wiley and sons, 1969.
6. Strain Gauge Primer- Perry and Lissner, McGraw Hill, 1962.

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5102					
TITLE OF THE COURSE	FINITE ELEMENT METHOD					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	2	-	60	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

- Introduce the various aspects of FEM as applied to engineering problems.
- Define the element properties such as shape function and stiffness matrix for the various elements
- Formulate element properties for 1D, 2D elements
- Use of FE tool in linear structural, heat transfer, and dynamics problems
- Analyze bars and trusses
- Analyze plane elasticity problems
- Formulate and solve dynamic problems

Laboratory Component

- Understand and formulate the problem based on given geometry and physics
- Know how to model, analyze mechanical systems using finite element analysis software
- To impart knowledge for creating 1D/2D/3D models using preprocessing of FE software
- To impart knowledge for creating 2D/3D models using CAD software and export to finite element software
- Learn the use of commercial software to solve complex problems

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Apply the weighted residual method and Rayleigh-Ritz method to approximate the solutions of simple problems	L3
CO2	Develop finite element formulations for bar and beam elements using linear and quadratic shape functions and use them in simple heat transfer problems	L3
CO3	Formulate and use iso-parametric, axisymmetric, serendipity elements and use natural co-ordinate systems	L3
CO4	Demonstrate the applications to solid mechanics problems and dynamic considerations	L3
CO5	Model and analyze mechanical systems using ANSYS software	L5

COURSE CONTENT:

MODULE 1	06 Hrs
Introduction to Finite Element Method - Introduction, Engineering Analysis, Convergence criteria, Vibrational formulations, weighted residual methods, Potential Energy 1D Bar Element, Admissible displacement function, Strain matrix, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain.	
MODULE 2	06 Hrs
One-Dimensional Elements - Analysis of Bars and Trusses, Basic Equations and Potential Energy Functional, 1-D Bar Element, Assembly Procedure, Boundary and Constraint Conditions, 2-D Bar Element, 3-D Bar Element, Beam Element, Hermite shape functions, 1D Heat transfer, Truss element, Test Problems and Applications.	
MODULE 3	08 Hrs
Two-Dimensional Elements - Analysis of Plane Elasticity Problems, Three- Noded Triangular Element (TRIA 3), Four- Noded Quadrilateral Element (QUAD 4), Higher Order Elements Axisymmetric Solid Elements- Analysis of Bodies of Revolution. Axisymmetric Quadrilateral Ring Element- Geometric representation, Admissible displacement functions, Element strain matrix, element stress recovery, Element stiffness matrix, Consistent nodal force vector: Body force, initial strain. Surface traction, Element equations. Test Problems – Assessment of Accuracy, Practical Applications.	
MODULE 4	08 Hrs

Three-Dimensional Elements-Applications to Solid Mechanics Problems: Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Shape functions for Higher Order Elements

MODULE 5

08 Hrs

Dynamic Considerations- Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

Laboratory Component:

Experiment 1 (Revision)	1-D Elements, Bar, Truss & Beam Elements, Static & Dynamic Analysis	06 Hours
Experiment 2	Geometric Modeling of 2-D geometry using Ansys, Import 2-D geometry from other Modeling software 2-D Elements, Triangular & Quadrilateral, Linear and Higher-Order elements, Meshing Techniques; Manual & Automatic Meshing in Ansys,	06 Hours
Experiment 3	Geometric Modeling of 3-D geometry using Ansys, Import 3-D geometry from other Modeling software 3-D Elements, Tetrahedral & Hexahedral, Linear and Higher-Order elements, Meshing Techniques in 3-D; Manual & Automatic Meshing in Ansys, Import mesh from Hypermesh,	06 Hours
Experiment 4	Analysis of Structures 2-D & 3-D: Static Analysis. Modal Analysis. Harmonic Analysis. Spectrum Analysis. Buckling Analysis, Analysis of Composites.	06 Hours
		24 Hours

TEXT BOOKS:

1. Rao S. S., Finite Elements Method in Engineering, 4th Edition, Elsevier, 2006.
2. Chandrupatla T. R., Finite Elements in Engineering, 2nd Edition, PHI, 2007
3. Lakshminarayana H. V., Finite Elements Analysis, Procedures in Engineering, Universities Press, 2004.

REFERENCES :

1. Reddy J.N., An Introduction to the Finite Element Method, McGraw - Hill International Edition, New York, 1993.
2. Bathe K. J. Finite Elements Procedures, PHI, 2002.
3. Cook R. D., et al. Concepts and Application of Finite Elements Analysis, Edition, Wiley & Sons, 2003

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5103					
TITLE OF THE COURSE	SOLID MECHANICS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	-	2	-	60	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To able to assess the stress/deformations for a given case of loading
2. To apply the yield criteria to assess whether the material has undergone yielding
3. To understand asymmetrical bending and the influence of shear Centre
4. To analyze beams of different cross sections for bending
5. To analyze bars of various cross sections for torsion
6. To understand the procedure for axisymmetric and thermal stress analysis
7. Demonstrate the ability to use commercial software to solve simple and complex structural problems.

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Laboratory Component

The student will be able to

1. To know how to model mechanical systems using finite element analysis software and analyse structural response.
2. To simplify structural problems and analyse using finite element software such as through plane stress/plane strain/ axisymmetric assumptions.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To identify & analyse plane stress / plane strain / axisymmetric problems	L1/L2/L3
CO2	To analyse the principal stresses principal strain and principal planes for generalised case of loading in an isotropic material	L3
CO3	To assess the plastic deformation using different yield criteria	L2
CO4	To identify the shear centre of a beam section	L2
CO5	To analyse the structure subjected to bending or torsion	L4
CO6	Design and analyse structures using hand calculation or using FEA	L5

COURSE CONTENT:

MODULE 1 - Analysis of Stress	08 Hrs
Introduction, The State of Stress at a point, Stress Components on an Arbitrary Plane, Principal Stresses, Stress Invariants, Mohr's Circles for the Three- Dimensional State of Stress, Mohr's Stress Plane, Planes of maximum shear, Octahedral Stresses, State of pure shear, Decomposition into hydrostatic and pure shear states, Cauchy's stress quadric, Lamé's Ellipsoid, The plane state of stress, Differential equations of equilibrium, Equations of equilibrium for Plane Stress State, Equations of equilibrium in cylindrical coordinates, axisymmetric stress state	
MODULE 2 - Analysis of Strain	06 Hrs
Introduction, Deformations, Change in length of a linear element, The state of strain at a point, Principal axes of strain and principal strains, Plane state of strain, Plane strain in polar coordinates, Compatibility conditions, Strain Deviator and its invariants ¹²	
MODULE 3 - Stress-strain relations	08 Hrs
Generalized statement of Hooke's law, Displacement Equations of Equilibrium, Theories of failure, Ideally Plastic Solid, Stress space and strain space – Deviatoric plane or π -plane, Yield Surfaces of Tresca and Von-Mises, Stress-strain relationship (Plastic flow), Prandtl-Reuss Equations	
MODULE 4 - Bending of Beams	06 Hrs
Straight beams and Asymmetrical Bending, Euler-Bernoulli Hypothesis, Shear centre or centre of flexure, shear stresses in a thin-walled open sections, shear centre of T or L sections, Bending of curved Beams	

MODULE 5 - Torsion, and Axisymmetric problems	08 Hrs
Torsion of general prismatic bars (Circular/Elliptical/Equilateral Triangular/Rectangular), Membrane Analogy, Torsion of thin walled tubes, Torsion of bars with thin rectangular sections, Centre of twist and flexural centre. Axisymmetric problems: Lamé's problem, Stresses in composite tubes-shrink fit, Rotating discs of uniform thickness, Discs of variable thickness, Rotating shafts and cylinders	

Laboratory Component:

Experiment 1	Identification of principal stresses and principal planes using MATLAB	04 hours
Experiment 2	Evaluation of normal stresses in straight beams as a result of thermal loading through MATLAB/FEA.	04 hours
Experiment 3	Comparison of axisymmetric analysis with Full 3D modelling using FEA.	04 hours
Experiment 4	Analysis of beams when it is subject to symmetrical / asymmetrical bending using FEA	04 hours
Experiment 5	Analysis of Torsion of bars of various cross section using FEA	04 hours
Experiment 6	Analysis a typical connecting rod or a pressure vessel using FEA	04 Hours
		24 Hours

Text Books:

1. Srinath , L. S. Advanced Mechanics of Solids , Tata McGraw-Hill Education, Third Edition, 2008.
2. Kazimi, S. M. A. Solid Mechanics, Tata McGraw-Hill Education, 2001
3. Allan F. Bower, Applied Mechanics of Solids, CRC Press, 2009

Reference Books:

1. Shames I.H and Pitarresi, J.M.P., Introduction to Solid Mechanics, PHI Publications, Third Edition, 1999.
2. Phillips, Durelli and Tsao, Analysis of Stress and Strain, McGraw Hill Book, 1958.

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5104					
TITLE OF THE COURSE	SPECIAL TOPICS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	-	04	-	-	48	2

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To present the fundamental principles and practices of AI , ML, Data Analytics and IOT
2. To address the real-world mechanical engineering problems using AI , ML, Data Analytics and IOT
3. To develop a basic understanding of these technologies and apply them to solve mechanical domain problems including Automotive, Aerospace and other Interdisciplinary areas.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's TaxonomyLevel
C01	Recognise the importance of AI & ML, Data sciences & IOT in Mechanical Engineering	L2
C02	Comprehend the ideas of AI and problem-solving techniques	L2
C03	Apply Machine Learning and Deep Learning algorithms	L3
C04	Apply Data Analysis algorithms	L3
C05	Apply IOT concepts to mechanical domain problems	L3

COURSE CONTENT:	
MODULE 1 Introduction to New Technologies	08 Hrs
Introduction to Artificial Intelligence, Machine Learning, Data Analytics & Internet of Things. Application of the Mechanical Domain areas such as Automobile, Aerospace & other interdisciplinary areas.	
MODULE 2 Machine Learning	10 Hrs
Introduction to Supervised Learning(Regression and Classification), Un-Supervised Learning (Clustering and Association), Reinforcement learning and Machine learning Algorithms(Linear Regression, Logistic Regression, Decision Tress, Random Forest, SVM,KNN, K-Means Clustering, Q-Learning)	
MODULE 3 Deep Learning	10 Hrs
Introduction to Deep Learning and Artificial Neural Network, Deep Neural Network (DNN), Convolution Neural Network (CNN), Recurrent Neural Network (RNN)	
MODULE 4 Data Analytics	10 Hrs
Introduction to Data Warehousing, Extract, Transform & Load (ETL), SQL & NOSQL	
MODULE 5 Internet of Things	10 Hrs
Introduction to Computer Networks and ISO, OSI Layers and TCP and IP Protocols. Introduction to Internet of Things, Introduction to Sensors, Actuator, Transducers, Gateway, IOT Architecture, Introduction to Node MCU and Arduino. Application of IOT in Home Mechanical, Aerospace and Automobile Industries.	

Text Books:

1. Mayur Ramgir, Internet of Things- Architecture, Implementation, and Security [Print Replica]Kindle Edition, Pearson
2. Manohar Swamynathan (Author), Mastering Machine Learning with Python in Six Steps; A Practical Implementation Guide to Predictive Data Analytics Using Python 1st ed, Kindle Edition, press.
3. Jojo Moolayil, Learn Keras for Deep Neural Networks: A Fast-Track Approach to Modern Deep Learning with Python 1st ed. Edition, Kindle Edition

Reference Books:

1. David L. Poole, Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
2. Nils J. Nilsson, the Quest for Artificial Intelligence, Cambridge University Press, 2009.
3. Richard E Neapolitan; Xia Jiang Artificial Intelligence: With an Introduction to Machine Learning, Chapman and Hall/CRC Press, 2018.
4. Sttuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, PearsonE ducation 2007.
5. Nagy Z. Artificial Intelligence and Machine Learning Fundamentals: Develop real worldapplications powered by the latest AI advances. Packt Publishing Ltd; 2018.

DEPARTMENT ELECTIVE-I

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5031					
TITLE OF THE COURSE	APPLIED MATHEMATICS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	-	--	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. To learn the various numerical schemes for curve fitting, solving linear equations and partial differential equations.
2. To study the solution to extreme problems using vibrational principle.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Solve problems using numerical methods. 17	L2
CO2	Solve and use various curve fitting techniques	L3
CO3	Solve and use the fundamentals of most commonly occurring situations in the form of ODE's and PDE's for real life applications.	L3
CO4	Solve and use various Numerical linear algebra techniques.	L3

COURSE CONTENT:	
MODULE 1 - Calculus of Variation:	06 Hrs
Introduction, The First Variation, Euler-Lagrange equation, Isoperimetric problems.	

MODULE 2 - Curve Fitting:	07 Hrs
Linear regression, Polynomial regression, General Linear Least Squares, Newton's Divided Differences, Lagrange interpolating polynomials, Inverse interpolation, spline interpolation, and Multidimensional interpolation.	
MODULE 3 - Ordinary Differential Equations	08 Hrs
Ordinary Differential Equations: Formulations of ordinary differential equations involving Mechanical engineering problems. Solutions- Equations of first order and first degree. Equations of first order and second degree. Bernoulli equation. Euler equation. Simultaneous linear differential equations	
MODULE 4 - Numerical solution of PDE's	08 Hrs
Laplace Equation, Solution technique, Boundary conditions, the control-volume approach, Heat conduction equation, explicit methods, a simple implicit method, Crank Nicolson method, parabolic equations in two spatial domains, Case studies.	
MODULE 5 - Numerical Linear algebra:	07 Hrs
Partition method, Croute's Triangularisation method. Eigen values and Eigen vectors. Bounds on Eigen Values. Jacobi method for symmetric matrices. Gauss Elimination, LU decomposition, Special Matrices and Gauss Seidel, Case studies.	

TEXT BOOKS:

1. Chapra, S.C. and Canale, R.P. Numerical Methods for Engineers, Sixth Edition, McGraw Hill.
2. Bruce van Brunt, The Calculus of Variations, Springer.

REFERENCES :

1. Chapra, S.C. Applied Numerical Methods with MATLAB, Seco1n8d Edition, Mc Graw-Hill.
2. Cheney W. and Kincaid, D. Numerical Mathematics and Computing, Sixth Edition, Brooks/cole

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5032					
TITLE OF THE COURSE	DYNAMICS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. Introduce the various aspects of dynamics as applied to engineering problems.
2. Formulate behavior/dynamics of machines under different loading conditions.
3. Use of Kinematic tools like CATIA/MATLAB/ANSYS/ABAQUS to understand the Kinematic and dynamic behavior of machines and solve vibration problems.
4. To study the Principles of Design in machines.
5. To introduce the various aspects Kinematics and dynamics of machines.
6. To learn mechanism for simple and complicated structures using FEA.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Study the basics of Kinematics and dynamics of machines	L1
CO2	Simulate the mechanism for simple and complicated structures using FEA and ADAMS	L3
CO3	Apply the tools of analytical dynamics with the main goal of developing mathematical models that describe the dynamics of systems of rigid bodies.	L3
CO4	Formulate equations of motion for complicated mechanical systems and solving these equations.	L3

C05	Demonstrate multi body dynamics in mechanical engineering design	L3
C06	Apply the Dynamics for conceptual design	L3

COURSE CONTENT:	
MODULE 1 Introduction to Dynamics of Machines	06 Hrs
Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, unique mechanisms. Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method, Numerical examples.	
MODULE 2 Principles of Dynamics	08 Hrs
Generalized Principles of Dynamics: Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamiltons equations, Hamiltons principle, Lagrange's, equation from Hamiltons principle, Derivation of Hamilton's equations, Numerical examples.	
MODULE 3 Synthesis of Linkages	07 Hrs
Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle. Numerical examples.	
MODULE 4 Dimensional Synthesis	07 Hrs
Analytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.	
MODULE 5 System Dynamics	08 Hrs
System Dynamics: Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Spatial Mechanisms: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles. Numerical examples.	

Text Books:

1. K.J.Waldron & G.L.Kinzel , “Kinematics, Dynamics and Design of Machinery”, Wiley India,2007.
2. Greenwood, “Classical Dynamics”, Prentice Hall of India, 1988.

Reference Books:

1. J E Shigley, “Theory of Machines and Mechanism” -McGraw-Hill, 1995
2. A.G.Ambekar , “Mechanism and Machine Theory”, PHI, 2007. 3. Ghosh and Mallick , “Theoryof Mechanism and Mechanism”, East West press

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5033					
TITLE OF THE COURSE	PRODUCT DEVELOPMENT					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are to:

1. Identify the customer needs, formulate the specifications and carry out need analysis.
2. Generate, screen and test the concepts.
3. Model the prototypes and carry out economic analysis
4. Explain the steps involved in product development process
5. Apply various methods for stimulating innovation of a product
6. Synthesize design with analysis to develop new product
7. Implement product principles in different organizations
8. Identify the design factors and processes as per customer specifications.
9. Provide a fundamental understanding of common principles, various standards & protocols

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COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Develop models by applying the concepts of product design theory	L3
C02	Solve problems independently and identification of customer needs for the product growth	L3
C03	Understand the process of product planning and specifications	L1
C04	Have a basic knowledge of concept generation, selection and testing	L1

C05	Identify the significance of product architecture and development economics	L2
C06	Apply embodiment principles in prototyping for small product business	L3
C07	Understand the product development by making a product and evaluate the salient features	L3

COURSE CONTENT:

MODULE 1 Introduction 06 Hrs

Product development- Characteristics of successful product development, Design and development of products, challenges of product development. A generic development process, front-end process.

Identifying Customer Needs- Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process.

MODULE 2 Product Planning & Specifications 08 Hrs

The product planning process- identify opportunities, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process.

Product Specifications- What are specifications, when are specifications established, establishing target specifications, setting the final specifications.

MODULE 3 Concept Generation, selection and testing 08 Hrs

Concept generation -clarify the problem, search externally & internally, explore systematically, reflect on the results and the process.

Concept Selection- Overview of methodology, concept screening, and scoring.

Concept Testing- purpose of concept test, choose a survey population & format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process.

MODULE 4 Product Architecture & Development Economics 07 Hrs

Product architecture- implications & establishing the architecture, variety and supply chain considerations, platform planning and related system level design issues.

Product Development Economics- Elements of economic analysis, Sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.

MODULE 5 Prototyping 07 Hrs

Prototyping basics, principles of prototyping, technologies, planning for prototypes.

Text Books:

1. Karl.T.Ulrich and Steven D Eppinger, Product Design and Development-Irwin/McGrawHill -2000.
2. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly - 2002

Reference Books:

1. Chitale, A. C. and Gupta, R. C., Product Design and Manufacturing, PH1, 3rd Edition, 2003.
2. Tim Jones and Butterworth Heinmann, New Product Development, Oxford, UCI,1997

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5034					
TITLE OF THE COURSE	DATA VISUALIZATION					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. Review of viewing transformations
2. Study the clipping algorithms
3. Representing curves, surfaces and solids
4. Study visual realism principles

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Learned to generate mathematical representation of surfaces and Visualizations appropriate to the specific task and data source	L3
CO2	Creating transformations and clipping of multiple versions of visualizations using mathematical techniques.	L3

COURSE CONTENT:

MODULE 1 Viewing Transformations		06 Hrs
Representation of points, Transformations: Rotation, Reflection, Scaling, Combined Transformations, Translations and Homogeneous Coordinates, A geometric interpretation of homogeneous coordinates, Over all scaling, Points at infinity, Rotation about an arbitrary point, Reflection through an arbitrary line. Viewing transformation, Clipping - points, lines, Text, Polygon, Cohen, Sutherland line clipping, Sutherland, Hodgmen algorithm.		
MODULE 2 Types and Mathematical Representation of Curves		08 Hrs

Curve representation, Explicit, Implicit and parametric representation. Nonparametric and parametric representation of Lines, Circles, Ellipse, Parabola, Hyperbola, Conics. Parametric representation of synthetic curve, Hermite cubic splines, , Bezier curves: Blending function, Properties, generation, B-spline curves- Cox-de Boor recursive formula, Properties, Open uniform basis functions, Non-uniform basis functions, Periodic B-spline curve.	
MODULE 3 Types and Mathematical Representation of Surfaces	08 Hrs
Surface entities- Plane, Ruled, surface of revolution, Tabulated cylinder, Bezier surface, B-spline surface, Coons patch, Off set surface, Surface representation, Parametric representation of analytic surface- plane, Ruled surface, Surface of revolution, Tabulated cylinder, Parametric representation of synthetic surfaces, Hermite bicubic surface, Bezier surface, B-spline surface, Coons surface, Offset surface.	
MODULE 4 Types and Mathematical Representation of Solids	07 Hrs
Solid entities- block, Cylinder, cone, Sphere, wedge, Torus, Solid representation, Fundamentals of solid modeling, Set theory, Regularized set operations, Set membership classification, Half spaces, Basic elements, Building operations, Boundary representation, Basic elements, Building operations, Constructive solid geometry, Basic elements, Building operations, Sweep representation.	
MODULE 5 Visual Realism	07 Hrs
Visibility of object views, Visibility techniques: minimax test, Containment test, Surface test, Silhouettes, Homogeneity test, Sorting, Coherence, Hidden line priority algorithm, Hidden surface removal- Z-buffer algorithm, Warnock's algorithm, Hidden solid removal - ray tracing algorithm. Shading, Shading models, Diffuse reflection, specular reflection, Ambient light, Shading surfaces Constant shading, Gourmand shading, Phong shading, Shading enhancements, Shading Solids, Ray tracing for CSG, z- buffer algorithm for B-rep and CSG, octree encoded objects, Colouring- RGB, CMY, HSV, HSL colour models	

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TEXT BOOKS:

1. Ibrahim Zeid, CAD/CAM-Theory and Practice, McGraw Hill, 2006
2. Roger's Adams, Mathematical Elements for Computer Graphics, McGraw Hill, 1990

REFERENCES :

1. Xiang Z, Plastock, R. A, Computer Graphics, Schaums Outlines, McGraw Hill. 2007.
2. Foley, Van- Dam, Finner and Hughes, Computer Graphics principles and practice, Addison Wesley, 1990

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5035					
TITLE OF THE COURSE	DIGITAL CONTROL SYSTEMS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are

1. Ability to carry out the stability analysis and control systems.
2. Ability to learn processors for industrial applications.
3. To understand the state space approach
4. To understand PID controllers

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Solve problems using z-transform, inverse z- transform techniques.	L3
CO2	Know the advantage of state variable technique, controllability, observability for effective design of controller using digital technique 27	L3
CO3	Develop competency in controller design	L3
CO4	Analyse the time response of controllers	L4

COURSE CONTENT:	
MODULE 1 Sampling and holding	06 Hrs
Sample and hold device D/A, A/D conversion – Z transform – Inverse Z transform – Properties – Pulse transfer function and response between sampling intervals – Reconstruction.	
MODULE 2 State equations of discrete data systems	08 Hrs

State transition equations – Relationship between state equation and transfer functions - Characteristic equations – Eigen value – eigen vector –Diagonalization of Matrix – Jordan canonical form – Methods of computing state transition matrix –State diagram – Decomposition of discrete data transfer function	
MODULE 3 Controllability and observability of linier time invariant discrete data systems	08 Hrs
Relationships between controllability, observability and transfer function-Stability of linier discretecontrol system – Stability tests – Bilinear transformation method – Jury's stability test	
MODULE 4 Correlationbetween time response and root locations in S plane and Z plane	07 Hrs
Direct design in Z and W plane – State space design – Design via pole placement, digital PID controller design.	
MODULE 5 Selection of processors	07 Hrs
Mechanization of control algorithms – Merits and demerits – Applications of temperature control – Control of electric drives.	

Text Books:

1. Ogata, K. Discrete Time Control Systems, Pearson Education Asia, 2001
2. Gopal, M. Digital Control and State Variable Methods, Tata McGraw Hill,1999

Reference Books:

1. Kuo, B.C. Digital Control Systems, Oxford University Press, 1992
2. Gopal, M. Digital Control Engineering, Willey Eastern Ltd.1989
3. Laboratory manual, school of engineering, DSU

DEPARTMENTAL ELECTIVES – II

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5036					
TITLE OF THE COURSE	ROBOTICS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To understand the basic engineering knowledge for the design of robots
2. To describe spatial descriptions and transformations
3. To explain manipulator kinematics and trajectory generation concepts
4. To discuss the robot programming for various applications
5. To teach students about basic robotics through lectures and simulations

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
	29	
CO1	Apply the basic engineering knowledge for the design of robots	L3
CO2	Illustrate the spatial descriptions and transformations	L2
CO3	Apply the manipulator kinematics and trajectory generation concepts	L2
CO4	Demonstrate the programming principles for robot control.	L3
CO5	Demonstrate the process of building a robot using MatLab	L4
CO6	Demonstrate the path following and trajectory control modeling using Simulink	L3

COURSE CONTENT:	
MODULE 1 Introduction	06 Hrs
A brief history of robotics, robot anatomy, work volume, links, joint and joint notation scheme, degrees of freedom, arm configuration, wrist configuration, end- effector, robot drive systems, control systems, precision of movement, robotic sensors, robot programming and work cell control, robot applications.	
MODULE 2 Coordinate Frames, Mapping and Transforms	08 Hrs
Coordinate Frames, Mapping: Mapping between rotated frames, mapping between translated frames, Mapping between rotated and translated frames, description of objects in space, transformation of vectors; rotation and translation of vectors, combined rotation and translation of vectors, composite transformation, fundamental rotation matrices, Euler angle representation.	
MODULE 3 Robot Kinematics and Dynamics	08 Hrs
Introduction, description of links and joints, kinematic modeling of the manipulator, Denavit-Hartenberg notation, kinematic relationship between adjacent links, 2- DOF planar manipulator arm, kinematic model of a cylindrical arm, articulated arm kinematic model, robot arm dynamics, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation.	
MODULE 4 Path planning & Programming	07 Hrs
Introduction, general considerations in path description and generation, joint-space schemes, cartesian-space schemes, geometric problems with Cartesian paths, description of paths with a robot programming language, methods of robot programming, lead through programming methods, robot program as a path in space, motion interpolation, wait, signal, and delay commands, branching.	
MODULE 5 Robot Sensors and Machine Vision	07 Hrs
Transducers and sensors, sensors in robotics, tactile sensors; touch and force sensors, force sensing wrist, proximity and range sensors, uses of sensors in robotics, introduction to machine vision, sensing and digitizing, imaging devices, lighting techniques, analog to digital signal conversion, image storage, image processing and analysis	

Text Books:

1. John J. Craig, Introduction to Robotics, Third Edition, Pearson India Education Services Pvt.Ltd, 2015
2. Mikell P Groover, Mitchel Weiss, Industrial Robotics, Second Edition, McGraw Hill Education(India) Private Limited, 2012
3. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

Reference Books:

1. Fu, K. S., Gonzalez R. C., and Lee C.S.G., Robotics Control, Sensing, Vision and Intelligence, McGraw Hill, Thirteenth reprint 2015.
2. Schilling R. J., Fundamentals of Robotics, Analysis and Control, PHI, 2006.
3. Niku, S. B. Introduction to Robotics Analysis, Systems, Applications, Pearson Education, 2008.
4. R K Mittal, I J Nagrath, Robotics and Control, Tata McGraw-Hill Education, 2003

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5037					
TITLE OF THE COURSE	SENSORS AND SIGNAL CONDITIONING					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To instill knowledge of advanced sensor systems.
2. To provide an application oriented approach in instrumentation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the characteristics of instrumentation system	L2
CO2	Identify the most suitable method of sensing and transduction for an application.	L2
CO3	Describe various types magnetic sensors and their applications	L1
CO4	Discuss analog and digital instrumentation aspects	L2
CO5	Design instrumentation and associated data acquisition system.	L3
CO6	Develop data acquisition system for any typical mechanical applications	L3

COURSE CONTENT:	
MODULE 1 Basic Concepts	06 Hrs
Basic Concepts of Measurements and characteristics of an Instrumentation System-System configuration, Problem analysis, Basic characteristics of measuring, Calibration, Generalized measurements, Zero order, First order, second order system, Dead time element.	

MODULE 2 Sensors and Transducers	08 Hrs
Electromechanical sensors, Resistance type, Potentiometer, Strain gauge, Resistance thermometer, RTD, Inductance type, Capacitance type, Piezo Electric type.	
MODULE 3 Magnetic sensors	07 Hrs
NMR, MRI, Fiber optic sensors, Opto electronic sensors, CCD, Digital transducers.	
MODULE 4 Analog and Digital Instrumentation	07 Hrs
Operational Amplifiers, Signal generation, Signal processing, Filtering and signal analysis.	
MODULE 5 Data Acquisition, Conversion, Transmission and Processing	08 Hrs
Signal Conditioning of the inputs – Single channel and Multichannel data acquisition, Data conversion, Multiplexers, Sample and hold circuits, Data transmission systems, Pulse code formats, Modulation techniques, Telemetry system.	

Text Books:

1. Nubert, H.K.P., Instruments Transducers, Clarendon Press, Oxford, 1963
2. Ernest O. Doebelin, Measurement System Application & Design McGraw Hill, New York, 1983.

Reference Books:

1. Ramon Pallas-Areny, John G. Webster, Analog Signal Processing, A Wiley Interscience Publication, John Wiley & Sons, INC
2. Fernando E. Valdes-Perez Ramon Pallas-Areny, Microcontrollers, CRC Press, Taylor and Francis Group

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5038					
TITLE OF THE COURSE	DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To understand fundamentals of Hydraulic and Pneumatic systems
2. To design simple Hydraulic and Pneumatic circuits.
3. To design circuits for low cost automation. Demonstrate ability to make use of commercial software to solve complex problems.
4. Demonstrate ability to make use of commercial software to solve complex problems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Comprehend the principles, features and functions of hydraulic pumps and actuators.	L3
C02	Understand the concepts of flow control valves and regulators.	L2
C03	Realize the different types of hydraulic circuits and systems, and design the same.	L3
C04	Know the principles, features and functions of pneumatic pumps and actuators.	L3
C05	Recognize the working of different pneumatic circuits and systems, and design pneumatic circuits and systems.	L5
C06	Design, develop and analyse different types of hydraulic and pneumatic circuits and real systems.	L3

COURSE CONTENT:	
MODULE 1 Hydraulic Systems and Actuators	06 Hrs
Basic principles- Hydraulic Principles. Hydraulic Power Generators- Selection and specification of pumps, pump characteristics. Hydraulic Actuators - Linear, Rotary - Selection Characteristics.	
MODULE 2 Control and Regulation Elements	08 Hrs
Hydraulic Valves: Pressure, Flow, Direction Controls- Proportional Control valve. Fluid power symbols.	
MODULE 3 Design of Hydraulic Circuits	08 Hrs
Reciprocating, Quick return, Sequencing, synchronizing and other industrial circuits like press circuits - hydraulic milling machine - grinding, planning, copying, forklift, earth mover circuits - design and selection of components - safety and emergency mandrels. Selection and sizing of components-calculation of frictional head loss-equivalent length for various components-actuator load calculation- pump sizing.	
MODULE 4 Pneumatic Systems and Actuators	07 Hrs
Pneumatic system fundamentals: FRL, actuators and valves. Logic Circuits - Position - Pressure Sensing, switching, electro-pneumatic.	
MODULE 5 Design of Pneumatic Circuits	07 Hrs
Design of Pneumatic circuits using - Karnaugh maps. Cascade-Step counter. Installation, Maintenance and Special Circuits- Pneumatic equipment - selection of components - design calculations -application - fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation.	

Text Books:

1. Majumdar, S. R. Oil hydraulics and Pneumatics, Tata McGraw Hill, 2003.
2. Bolton, W. Pneumatic and hydraulic systems, Butterworth Heinemann, 1997.

Reference Books:

1. Anthony Esposite, Fluid Power with Applications, Pearson Education, 2000.
2. Andrew Parr, Hydraulics and Pneumatics, Jaico, 1999.
3. Laboratory Manual, School of Engineering, DSU.

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5039					
TITLE OF THE COURSE	LEAN MANUFACTURING					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. Introduce the various aspects of lean Manufacturing like just in time, Kanban systems,
2. Understanding the Benefits of lean manufacturing, Types of wastes, Reduction of wastes.
3. Understanding the system manufacturing, manufacturing strategy, design considerations for manufacture component and quality systems.
4. Identify the strategic issues like Training. Lean accounting, Activity based costing Product costing materials for effective manufacturing and make a future state for lean manufacturing.
5. Use of Opportunity to learn the fundamental principles of lean in manufacturing

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Illuminate the Brief history of lean manufacturing, Just in time production, Toyota systems, Kanban systems	L2
CO2	Describe the lean manufacturing for Assessment tools, Implementing lean manufacturing and Science behind lean manufacturing.	L2
CO3	Evaluating the Lean accounting like Product costing, Volume adjusted costing and Focused factory concept.	L3
CO4	Explain the Group technology coding classification , Kaizen, 5S, TPM Automation , Yoko poko , Design Root cause analysis	L2

	,Failure models and effects	
C05	Analysing the lean manufacturing by visiting implemented industry.	L5
C06	Evaluating and conducting a mini project to solve realistic engineering problems on lean manufacturing.	L3

COURSE CONTENT:

MODULE 1 General		06 Hrs
Brief history of lean manufacturing, Just in time production, Toyota systems, Kanban systems, Kanban rules, Benefits of lean manufacturing, Types of wastes, Reduction of wastes.		
MODULE 2 Lean manufacturing		08 Hrs
Principles - Basic tools - Techniques - Definition - Assessment tools- Implementing lean manufacturing – Science behind lean manufacturing – Capacity utilization - Variability – Delivery		
MODULE 3 Strategic issues:		08 Hrs
Actions - Issues - Focus - Leadership - Management of teams – Training. Lean accounting: Activity based costing - Product costing - Volume adjusted costing – Focused factory concept – Building strategic advantage through enterprise wide		
MODULE 4 Value stream and process mapping		07 Hrs
Overview - Where to use - Step by step approach –How to use – Reduce stream mapping – Present and future states - VSM symbols – Process mapping – Detailed instructions - limits – facilitation.		
MODULE 5 Cellular manufacturing:		07 Hrs
Work cell – Cell design - Facility planning – Plant layout – Balancing the work in work cells – Tact time – Defining - Benefits - Uses - Limitations –Facilities planning tools. Group technology coding classification - Productivity Improvement Aids - Kaizen – Kanban - 5S - TPM - Automation - Jidoka – Mistake proofing – Yoko poka Design Root cause analysis - Failure models and effects.		

Text Books:

1. Taiichi Ohno, (1988), The Toyota Production System (Beyond Large Scale production),
2. Portland, Oregon Productivity Press

Reference Books:

1. Kigoshi Suzaki, (1988), The New Manufacturing Challenge, Free Press, New York.
2. Shigeo Shing, (1989), Study of Toyota Production System, Portland, Oregon

SEMESTER	I					
YEAR	I					
COURSE CODE	22MDE5040					
TITLE OF THE COURSE	SMART MATERIALS AND STRUCTURES					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. Understand the concept of MEMS and Microsystems.
2. Understand the diverse technological and functional approaches and applications.
3. Provides an insight of micro sensors, actuators and micro fluidics.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand the physical properties of smart materials.	L2
C02	Study the characteristics of the system using sensors and actuators.	L2
C03	Analyse the responses of Static and Dynamic systems	L3
C04	Design, analyse and fabricate smart structures for various applications.	L3
C05	Determine the vibration characteristics of the systems using sensors Experimentally	L5
C06	Detect damage using Electro-Mechanical Impedance (EMI) Technique	L3

COURSE CONTENT:	
MODULE 1 Overview of Smart Materials	06 Hrs
Overview of Smart Materials, Structures and Products Technologies. Smart Materials (Physical Properties) - piezoelectric materials, magneto strictive, electro strictive materials, magneto electric materials. Magneto rheological fluids, electro rheological fluids, shape memory materials, fiber-optic sensors.	
MODULE 2 Sensors and Actuators	08 Hrs
Smart Sensor, Actuator and Transducer Technologies - smart sensors- accelerometers, force sensors, load cells, torque sensors, pressure sensors, microphones, impact hammers, MEMS sensors, sensor arrays smart actuators: displacement actuators, force actuators, power actuators, vibration dampers, shakers, fluidic pumps, motors smart transducers, ultrasonic transducers, sonic transducers, air transducers.	
MODULE 3 Measurement and Control	08 Hrs
Measurement, Signal Processing, Drive and Control Techniques- quasi-static and dynamic measurement methods, signal-conditioning devices, constant voltage, constant current and pulse drive methods; calibration methods, structural dynamics and identification techniques, passive, semi-active and active control, feedback and feedforward control strategies.	
MODULE 4 Smart Structures	07 Hrs
Design, Analysis, Manufacturing and Applications of Engineering Smart Structures And Products - Case studies incorporating design, analysis, manufacturing and application issues involved in integrating smart materials and devices with signal processing and control capabilities to engineering smart structures and products.	
MODULE 5 Applications	07 Hrs
Emphasis on structures, automation and precision manufacturing equipment, automotive, consumer products, sporting products, computer and telecommunications products, medical and dental tools and equipment.	

Text Books:

1. Srinivasan, A. V., Smart Structures: Analysis and Design, Cambridge University Press,Cambridge; New York, 2001
2. Culshaw, B., Smart Structures and Materials, Artech House, Boston, 1996.

Reference Books:

1. Uchino, K., Piezoelectric Actuators and Ultrasonic Motors, Kluwer Academic Publishers, Boston, 1997.
2. Otsuka, K. and Wayman, C. M., Shape Memory Materials – Cambridge University Press, Cambridge; New York, 1996.
3. Gandhi, M. V. and Thompson, B.S, Smart Materials and Structures, Chapman and Hall, London; New York, 1992

SEMESTER II

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5201					
TITLE OF THE COURSE	ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGY					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	-	4	-	84	5

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To study the behavior of various materials with different structure-property relationship
2. To introduce the various aspects Ceramics, composites, MMCS
3. To learn fabrication and operational skills and applications for Composite materials
4. To have overview of surface engineering and other treatments for materials environment.

Laboratory Component:

1. To understand the preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process.
2. To comprehend the 3D printing of polymer/metal/ceramic samples.
3. To design new materials using ANSYS Material Designer.
4. To perform mould flow analysis
5. To work on open ended problems/projects related to advanced materials.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the properties of materials and its structure-property relationship	L2
CO2	Understand the principles underlying the functional and mechanical behavior of ceramic materials	L2

C03	Develop competency in composite manufacturing techniques, and be able to select the appropriate technique for manufacture of various composite products.	L3
C04	Analyse real life surface failure problems and determine the correct surface engineering solution.	L4
C05	Create a Representative Volume Elements and compute the responses while exposing it to several macroscopic load cases.	L3
C06	Prepare a new composite specimen using advanced materials.	L3

COURSE CONTENT:	
MODULE 1 Introduction	06 Hrs
Introduction- Properties of Materials, Structure property relationship, Newer Materials – Ceramics and Composite materials, Ceramics – Fine ceramics, Types of ceramics, Structure of Ceramics, Properties of Ceramics, and Applications.	
MODULE 2 Composite Materials	06 Hrs
Composite Materials- Types – Metal matrix Composites (MMC), Ceramic Matrix Composites (CMC), Polymeric composites Structure, Properties and Applications of different composite materials.	
MODULE 3 Processing of Metal matrix Composites (MMC), Ceramic Matrix Composites (CMC)	08 Hrs
Processing of MMC & CMC, Vacuum infiltration, squeeze casting, pressure die casting, Rheo-casting, Compo-casting, Super plastic forming	
MODULE 4 Processing of Polymer matrix Composites (PMC)	08 Hrs
Processing of PMC-Hand Lay Up, Bag Molding Process, Autoclave molding, Compression molding, Pultrusion, Filament winding, Resin Transfer molding, Injection molding.	
MODULE 5 Surface Engineering	08 Hrs
Surface Engineering- Surface quality & integrity, concepts, Mechanical treatment, Thermal & Thermo-chemical treatment. Thermal Spraying Processes and Applications- Vapor depositions processes and applications, Ion-treatment, Laser Treatment.	

Laboratory Component:

Experiment 1	Preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process.	12 Hours
Experiment 2	Preparation of polymer/metal/ceramic samples using 3D printing.	12 Hours
Experiment 3	Designing new materials for various applications using ANSYS Material Designer.	12 Hours
Experiment 4	Mould flow analysis using ANSYS	12 Hours
	Total	48 Hours

Text Books:

1. Paul Degarmo, E. Black, J.T. and Ronald A Kohser, Materials and Processing in Manufacturing, JohnWiley & Sons, 2011.
2. Minoru Taya, and Richard J. Arsenault, Metal Matrix Composites, Elsevier Science & Technology, 1989
3. Mallick, P.K. Fiber-Reinforced Composites: Materials, Manufacturing, and Design, Third Edition, CRC Press, 2007

Reference Books:

1. Schwartz, M.M. Composite Materials Handbook, Second Edition, McGraw Hill Higher Education, New York, 1995
2. Tadeusz Burakowski and Tadeusz Wierzchon, Surface Engineering of Metals: Principles, Equipment, Technologies, CRC Press, 1998

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5202					
TITLE OF THE COURSE	MECHANICS OF COMPOSITE MATERIALS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the course are:

1. to tailor a composite to get desired characteristics (such as orthotropy/transverse isotropy/quasi- isotropy)in a composite
2. to estimate the lamina properties from the constituents through micromechanical relations
3. to evaluate the stresses/strains in a lamina for given case of loading
4. to assess whether the lamina has undergone failure for a given state of loading
5. to predict the properties of laminate based on the laminate configurations
6. to predict the failure of laminate based on failure analysis of lamina
7. to assess influence of temperature and humidity on the degradation of properties and failure of laminates

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	To identify the class of composite materials (isotropic/orthotropy/anisotropy)based on its structure/configuration	L1
C02	To estimate the properties of lamina from constituents	L2
C03	To assess the failure of lamina for given loading condition	L3
C04	To assess the laminate properties for a given stacking sequence	L2

C05	To analyse the failure of laminate for given case of loading	L4
C06	To design a composite configuration for any given case of loading taking into account the process/environment induced stresses etc	L5

COURSE CONTENT:

MODULE 1 Introduction and Micromechanics of a lamina	08 Hrs
Introduction to Composite Materials-Definition and Characteristics, Historical Development, Applications, Advantages and Limitations. Structural Performance of Conventional Materials, Geometric and Physical Definitions, Material Response under Load, types and Classifications of composite Materials, Lamina and Laminate , scales of Analysis, Basic lamina properties, Degree of Anisotropy. Micromechanical relationship for evaluation of lamina level properties from the constituents	
MODULE 2 Micro Mechanics of a lamina	10 Hrs
Elastic Behavior of Composite Lamina -Stress- Strain relations, Relations between Mathematical and Engineering Constants, Stress- Strain Relations for a Thin Lamina (2-D), Transformation of stress and stain (2-D, 3-D), Transformation of Elastic Parameters (2-D, 3-D), Transformation of stress and strain relations in terms of Engineering Constants (2 -D), Transformation relations for Engineering Constants (2 – D).	
MODULE 3 Failure theories of an orthotropic lamina	10 Hrs
Strength of Composite Lamina-Introduction, Failure Theories, Maximum Stress Theory, Maximum Strain Theory, and Energy based Interaction Theory, Interactive Tensor Polynomial Theory, Failure- Mode – Based Theories, Failure Criteria for Textile Composites, Computational Procedure for Determination of Lamina Strength, Evaluation and Application of lamina Failure Theories.	
46	
MODULE 4 Macro Mechanics of laminates	10 Hrs
Laminate Terminologies, Definitions, Elastic behavior of Multidirectional Laminates-Basic Assumptions, Strain – Displacement Relations, Stress- Strain Relations of a Layer within a laminate, Force and Moment Resultants, General Load –Deformation Relations: Laminate Stiffness, Inversion Load –Deformation Relations: Laminate Compliances, symmetric Laminates, Balance Laminates, Orthotropic Laminates, quasi-isotropic Laminates, Laminate Engineering Properties. Computational Procedure for Determination of Engineering Elastic Properties . Failure and Strength prediction of multi-directional laminates	

MODULE 5 Hygrothermal effects on laminates	10 Hrs
Hygrothermal Effects -Introduction, Hygrothermal Effects on Mechanical Behavior, Coefficient of thermal and Moisture Expansion of a Unidirectional Lamina, Hygrothermal Strains in a Unidirectional lamina, Hygro thermo elastic Load - Deformation and Deformation – Load relations, Hygro thermal Load- Deformation relations, Co-efficient of thermal and Moisture Expansion - Multidirectional Laminates and Balanced/Symmetric laminates. Physical significance of Hygrothermal forces and Moments, Hygrothermal Isotropy and Stability. Coefficient of thermal Expansion of Unidirectional and Multidirectional carbon/ Epoxy Laminates, Hygro thermo elastic stress Analysis of Multidirectional laminates, Residual stresses.	

Text Books:

1. Srinath , L. S. Advanced Mechanics of Solids , Tata McGraw-Hill Education, Third Edition,2008.
2. Kazimi, S. M. A. Solid Mechanics, Tata McGraw-Hill Education, 2001
3. Allan F. Bower, Applied Mechanics of Solids, CRC Press, 2009

Reference Books:

1. Shames I.H and Pitarresi, J.M.P., Introduction to Solid Mechanics, PHI Publications, ThirdEdition, 1999.
2. Phillips, Durelli and Tsao, Analysis of Stress and Strain, McGraw Hill Book, 1958.

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5203					
TITLE OF THE COURSE	ADVANCED MACHINE DESIGN					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	-	4	-	84	5

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To review the theory of failures, fatigue, creep, wear of surfaces
2. Understand fatigue crack growth, stress life, and LEFM approach
3. To identify and able to solve engineering design problems
4. To know the basics of surface failure, stress, and strength

Laboratory Component

1. To train commercial FE software to solve fatigue and fracture problems
2. To perform fatigue & fracture failure analysis of structures and components using finite element analysis software

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Review the theory of failures, fatigue, creep, wear of surfaces	L2
C02	Understand basic machine elements in machine design and understand their concepts in life estimation	L1
C03	Explain LEFM concepts and S-N approach for notched members	L1
C04	Understand the basics of surface failure, stress, and strength	L1
C05	Demonstrate fatigue failure of mechanical components using ANSYS software	L3
C06	Analyze fracture failure in different components using ANSYS software	L3

COURSE CONTENT:	
MODULE 1 Introduction	06 Hrs
Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples. High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods, and standard test specimens, Fatigue fracture surfaces, and macroscopic features, Fatigue mechanisms, and microscopic features.	
MODULE 2 Stress-Life (S-N) Approach	08 Hrs
S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation, and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. Strain-Life (ϵ -N) approach: Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties , Mean stress effects, Effect of surface finish, Life estimation by ϵ -N approach.	
MODULE 3 LEFM Approach	08 Hrs
LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis, and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches.	
MODULE 4 Fatigue from Variable Amplitude Loading	08 Hrs
Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction, and sequence effects, Cycle counting methods, Life estimation using stress life approach.	
MODULE 5 Surface Failure	06 Hrs
Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength.	

Course Content Lab Component:

Experiment 1	Fatigue analysis in ANSYS fatigue failure high cycle & low cycle fatigue life	12 Hours
Experiment 2	Fatigue Analysis of a plate with a hole using ANSYS Workbench	12 Hours
Experiment 3	Fatigue analysis of a formula SAE Hub	12 Hours
Experiment 4	fracture testing using Ansys workbench	12 Hours
Total		48 Hours

Text Books:

1. Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, and Henry O. Fuchs, Metal Fatigue in Engineering, John Wiley, New York, Second edition. 2001.
2. Jack. A. Collins, Failure of Materials in Mechanical Design, John Wiley, New York 1992.

Reference Books:

1. S. Suresh, Fatigue of Materials, Second Edition, Cambridge University Press, Cambridge, U.K. 1998
2. Julie. A. Benantine, Fundamentals of Metal Fatigue Analysis, Prentice-Hall, 1990
3. ASM Metals Hand Book, Fatigue and Fracture, Vol 19, 2002.

DEPARTMENTAL ELECTIVES –III

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5041					
TITLE OF THE COURSE	MECHATRONICS SYSTEM DESIGN					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To educate the student regarding integration of mechanical, electronic,
2. Electrical and computer systems in the design of CNC machine tools, Robots etc.
3. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems
4. To provide a hands-on experience to model a mechatronic system using mechanical and electronic components & to control them.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	This course makes the student to appreciate multi-disciplinary nature of modern engineering systems.	L3
CO2	After undergoing this course, the student is in a position to understand how mechatronics systems can be designed and developed.	L2
CO3	Students will learn to use different electronics components and how to control them for different applications.	L3
CO4	Students will learn how to acquire data from a real time system and how to use that for betterment of the system.	L3
CO5	Students will have a hands-on experience on how to integrate electronics in existing mechanical systems	L5

COURSE CONTENT:	
MODULE 1 Introduction	08 Hrs
Definition and Introduction to Mechatronic Systems. Modelling & Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Sensors and Transducers: Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.	
MODULE 2 Electrical Actuation Systems	10 Hrs
Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. System Models- Mathematical models - mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.	
MODULE 3 Signal Conditioning-	10 Hrs
Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, and Introduction to digital system processing, pulse-modulation.	
MODULE 4 MEMS and Microsystems	10 Hrs
Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging. Data Presentation Systems-Basic System Models, System Models, Dynamic Responses of System	
MODULE 5	10 Hrs
Advanced Applications in Mechatronics Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, Automated Manufacturing – Artificial intelligence in Mechatronics – Fuzzy Logic Applications in Mechatronics – Micro sensors in Mechatronics.	

Text Books:

1. Bolton, W. Mechatronics - Addison Wesley Longman Publication, 1999
2. Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture- Tata McGraw-Hill Education, 2002

Reference Books:

1. Kamm, L. J., Understanding Electro-Mechanical Engineering an Introduction to Mechatronics -IEEE Press, 1st Edition, 1996.
2. Shetty and Kolk, Mechatronics System Design- Cengage Learning, 2009.
3. Mahalik, Mechatronics- Tata McGraw-Hill Education, 2003.

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5042					
TITLE OF THE COURSE	MODELLING AND SIMULATION					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. Gain hands training and experience on Simulation software.
2. Developing skill to apply simulation software for goal driven system models.
3. Acquire working knowledge in statistical techniques, modelling approach and systems simulation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Develop performance models for real world systems and will be able to solvethose models through simulation and statistical techniques.	L3
C02	Understand the behavior of modelling system and create model for simulationstudies.	L2
C03	Develop skills to apply simulation software to construct and execute goal- driven system models.	L3
C04	Interpret the model and apply the results to resolve critical issues in a real world environment.	L3
C05	Demonstrate the software tools like MATLAB/PYTHON/ANSYS in solving real time problems and day to day problems.	L5
C06	Simulate the models for the purpose of optimum control by using software.	L3

COURSE CONTENT:	
MODULE 1 Introduction to Simulation	10 Hrs
Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study. Simulation studies related to Queuing systems, Inventory System etc.	
MODULE 2 General Principles	08 Hrs
Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling. Random Numbers theory	
MODULE 3 Random Variate Generation	10 Hrs
Inverse Transform Technique- Probability density functions, convolution methods- Erlang distribution, Acceptance Rejection Technique Optimization Via Simulation: Meaning, difficulty, Robust Heuristics, Random Search.	
MODULE 4 Data Input Modelling	10 Hrs
Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data, Multivariate and time series analysis. Verification and Validation	
MODULE 5 Output Analysis	10 Hrs
Types of Simulations with Respect to Output Analysis, Stochastic Nature of output data, Measures of Performance and their estimation, Output analysis of terminating simulation, Output analysis of steady state simulations. Software: Selection of Simulation Software, Simulation packages, Trend in Simulation Software.	

Text Books:

1. Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event system Simulation, Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203-2832-9.
2. Geoffrey Gordon, System Simulation, Prentice Hall publication, 2nd Edition, 1978, ISBN: 81-203-0140-4.
3. Averill Law & David M. Kelton, Simulation, Modelling and Analysis, TMH 3rd Edition, 2003.
4. Banks, J., J.S. Carson, B.L. Nelson, and D.M. Nicol, Discrete-Event System Simulation, Fourth Edition, Prentice-Hall, 2005.

Reference Books:

1. Gordon, G., System Simulation, PHI, 2006.
2. Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.
3. NarsinghDeo, Systems Simulation with Digital Computer, PHI Publication (EEE), 3rd Edition, 2004, ISBN : 0-87692-028-8
4. Deo, System Simulation with Digital computer, PHI, 1978.
5. Francis Neelamkovil, Computer Simulation and Modelling, John Wiley and Sons, 1987.

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5043					
TITLE OF THE COURSE	MECHANISM DESIGN					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. Study the kinematic analysis and synthesis of mechanisms using graphical and analytical method.
2. Understand the various quantitative and qualitative approaches for different mechanisms.
3. Able to formulate, identify and solve mechanism problems.
4. To get familiarized with the advanced mechanisms which are necessary to design for specific application.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand various mechanisms along with Grubler's equation & Grashof's condition.	L3
C02	Perform kinematic analysis of various mechanisms.	L4
C03	Execute mechanism synthesis for specified positions of various mechanism using graphical method	L3
C04	Perform mechanism synthesis for specified positions of various mechanism using analytical method	L3
C05	Execute the plane motion analysis of different mechanism	L4
C06	Demonstrate proficiency in the use of mechanism simulation software for kinematic analysis.	L3

COURSE CONTENT:	
MODULE 1 Kinematic Analysis of Mechanism	08 Hrs
Terminology, planar, Spherical and spatial mechanisms, mobility, Grashoff's law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms using various method Position Analysis - Vector loop Equations for 4 bar, Slider Crank, Six bar linkages, velocity and acceleration analysis	
MODULE 2 Kinematic Mechanism synthesis - Graphical Method	10 Hrs
Type, Number and Dimensional Synthesis, Function Generation, Path Generation and Motion Generation, Graphical Methods Two Position, Three Position and Four Position Synthesis of 4-bar Mechanism, Slider Crank Mechanism. Guiding a body through two, three and four distinct positions.	
MODULE 3 Kinematic Mechanism synthesis - Analytical Method	10 Hrs
Analytical Methods - Blotch's Synthesis, Freudenstein's Method, Coupler curve Synthesis, Cognate linkages - The Roberts – Chebychev theorem.	
MODULE 4 Advanced Kinematics of plane motion-I	10 Hrs
Introduction to plane motion. The Inflection circle, Euler – Savary Equation, Analytical and graphical determination of Bobillier's Construction, Collineation axis, Hartmann's Construction, Inflection circle for the relative motion of two moving planes, Application of the Inflection circle to kinematic analysis.	
MODULE 5 Advanced Kinematics of plane motion-II	10 Hrs
Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle	

Text Books:

1. Waldron, K.J. & Kinzel, G.L., Kinematics, Dynamics and Design of Machinery, Wiley, 2007.
2. Sandor, G. N and Erdman, A.G. Applied Mechanism Design, PHI, 1988.
3. Robert L Norton, Design of Machinery: An introduction to the Synthesis and Analysis of Mechanisms and Machines. Mcgraw-Hill, 3rd edition, 2003
4. Asok Kumar Mallik, Amitabha Ghosh, Gunter Ditttrich, Kinematic Analysis and Synthesis of Mechanisms, CRC Press, 1st edition, 1994.

Reference Books:

1. Hall, A.S., Kinematics and Linkage Design, PHI.
2. Ambekar, A.G., Mechanism and Machine Theory, PHI, 2007.
3. David H. Myszka, Machines and Mechanisms, Pearson Education, 2005.

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5044					
TITLE OF THE COURSE	INDUSTRIAL DESIGN AND ERGONOMICS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. Identify and quantify ergonomics problems and prioritize the outcomes
2. To complete value added systems and controls
3. Integrating ergonomics and anthropometric information into industrial design projects
4. Apply practical design methodology and process to design project and objects

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Students will be able to analyze and calculate the level of risk in a job causing stress, fatigue and musculoskeletal disorders and design appropriate work systems ⁵⁸	L3
C02	Develop design strategies, form detail concepts and communicate design proposals	L4
C03	Work as per Occupational Safety and Health Administration (OSHA) guidelines	L1
C04	Understand the significance of different physical factors like shape, size, color, form etc.	L2
C05	Respond to the socio-economic and cultural contexts of industrial design and the ethical duties.	L5

COURSE CONTENT:

MODULE 1 An approach to industrial design	08 Hrs
Elements of design structure for industrial design in engineering application in modern manufacturing systems. General approach to the man - machine relationship- workstation design-working position.	
MODULE 2 Shapes & Size Considerations	10 Hrs
Shapes and sizes of various controls and displays-multiple, displays and control situations - design of major controls in automobiles, machine tools etc., and design of furniture -redesign of instruments	
MODULE 3 Ergonomics and product design	10 Hrs
Ergonomics in automated systems- expert systems for ergonomic design. Anthropometric data and its applications in ergonomic, design-limitations of anthropometric data- use of computerized databases. Case study.	
MODULE 4 Visual Effects of Line and Form	10 Hrs
The mechanics of seeing- psychology of seeing general influences of line and form. Aesthetic Concepts. Concept of unity- concept of order with variety -concept of purpose style and environment-Aesthetic expressions. Style- components of style- house style, observation style in capital goods, case study	
MODULE 5 Color and light	10 Hrs
Colour and objects- color and the eye - colour consistency- colour terms- reactions to colour and colour continuation -colour on engineering equipment. Industrial Design in Practice - specifying design equipment- rating the importance of industrial design -industrial design in the design process.	

Text Books:

1. Mayall W.H., Industrial Design for Engineers - London Hiffee books Ltd. -1988.
2. Brain Shakel (Edited) - Applied Ergonomics HandBook, Butterworth Scientific. London, 1988.

Reference Books:

1. Bridger, R. C., Introduction to Ergonomics, McGraw Hill Publications, 1995.
2. Sanders & McCormick, Human Factor Engineering, McGraw Hill Publications, 6th edition, 2002.

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5045					
TITLE OF THE COURSE	ADDITIVE MANUFACTURING					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are to:

1. Understand importance of additive manufacturing in advance manufacturing process.
2. Explore the potential of additive manufacturing in different industrial sectors
3. Apply 3D printing technology for additive manufacturing
4. Acquire knowledge, techniques and skills to select relevant additive manufacturing process
5. Familiarize with various materials that are used in additive manufacturing
6. Know the principles, methods, possibilities and limitations of additive manufacturing process

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Define the various process & materials used in Additive Manufacturing	01
C02	Identify, analyse and solve problems related to Additive Manufacturing processes.	02
C03	Apply technique of CAD and reverse engineering for geometry transformation in Additive Manufacturing	03
C04	Analyse and select suitable process to carry out improvement in Additive Manufacturing	04
C05	Apply knowledge of Rapid tooling in additive manufacturing for various applications	03

C06	Design and fabricate working models for the conceptual applications.	06

COURSE CONTENT:	
MODULE 1 Introduction	08 Hrs
Overview, history, Basic principle, advantages of additive manufacturing, Procedure of product development in additive manufacturing, Classification, Materials used and challenges in Additive Manufacturing, Tooling, Applications	
MODULE 2 Additive Manufacturing Processes	10 Hrs
Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM), Micro- and nano-additive	
MODULE 3 Pre-Processing in Additive Manufacturing	10 Hrs
Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, Transformations, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials, pre heating of powders.	
MODULE 4 Post-Processing in Additive Manufacturing	10 Hrs
Post-processing equipment's, support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques	
MODULE 5 Rapid Tooling	10 Hrs
Introduction to Rapid tooling, classification, Direct and Indirect rapid tooling methods, Applications of additive manufacturing in rapid prototyping & rapid manufacturing, repairing and coating. Process optimization factors influencing accuracy, data preparation errors, Part building errors, Error in finishing & influence of build orientation.	

Text Books:

1. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
2. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010.
3. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.

Reference Books:

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007
2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006
3. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018

DEPARTMENT ELECTIVES IV

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5046					
TITLE OF THE COURSE	RESEARCH METHODOLOGY					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To understand the different aspects of social and managerial research.
2. To understand the approach and methods of managerial research.
3. To develop a thorough understanding of the fundamental theoretical ideas and research.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	This course makes the students to develop understanding on various kinds of research, objectives of doing research, research process, research designs and sampling.	L3
C02	The Students will be able to have basic knowledge on qualitative research techniques	L2
C03	The students will be able to have adequate knowledge on measurement & scaling techniques as well as the quantitative data analysis	L3
C04	The students will be able to have basic awareness of data analysis- and hypothesis testing procedures	L3
C05	The students will be able to have knowledge on Report writing, format of reports	L5
C06	The students will be able to have basic knowledge on Research design and role of literature, importance of research and its role.	L3

COURSE CONTENT:	
MODULE 1 Meaning of research	08 Hrs
Nature and scope of research, the research process and types of research, Definition of research problem-methods of problem formulation. Role of literature review in formulation of research problem, Research design, Uses and applications, Types of research designs, Exploratory, descriptive, experimental research designs.	
MODULE 2 Survey and sample study	10 Hrs
Sampling theories- random sampling and non-random sampling, Different methods of random and non-random sampling-sample size decisions, factors influencing sample size decision, Optimum sample size, Pilot survey.	
MODULE 3 Methods and techniques of data collection	10 Hrs
Observation and survey methods, Tools of data collection, Questionnaire and interview schedule, Questionnaire preparation, attitude measurement, Scaling techniques, Different types of scales, Validity and reliability of scale, Scale values.	
MODULE 4 Field work and data processing	10 Hrs
Classification and tabulation, Data summarization, analysis and interpretation of data, Univariate analysis, bivariate analysis, correlation and regression analysis, testing of hypothesis, Parametric and non-parametric tests, multivariate analysis, Factor analysis, discriminate analysis, conjoint analysis, clusters Analysis.	
MODULE 5 Report writing	10 Hrs
Types of reports, Substance of report, format of reports, Executive summary, Content of the report, Bibliography, References, Presentation of reports.	

Text Books:

1. Poulin V Young, Scientific social Surveys and Research, Prentice Hall of India, New Delhi, 1984.
2. Kothari C.R, Research Methodology- Methods and Techniques, Vishwa Prakashan, New Delhi, 2001.

Reference Books:

1. Gibaldi, Joseph, MLA Handbook for Writers of Research Papers, Affiliated East West Press Pvt. Ltd., New Delhi 2000.

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5047					
TITLE OF THE COURSE	EMBEDDED SYSTEMS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. To introduce the technologies behind embedded computing systems.
2. To introduce and discuss various software components involved in embedded system design and development.
3. To expose students to the recent trends in embedded system design.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the role of individual components involved in a typical embedded system	L2
CO2	Understand the electronic and mechanical components used in automobile systems	L2
CO3	Analyse the characteristics of different computing elements and select the most appropriate one for an embedded system	L3
CO4	Develop simple tasks to run on an RTOS	L4

COURSE CONTENT:	
MODULE 1 Fundamentals of Embedded Systems	08 Hrs
Complex systems and microprocessors- Embedded system design process Specifications- architecture design of embedded system- design of hardware and software components- structural and behavioral description.	

MODULE 2 Hardware Software Co-Design and Program Modelling	10 Hrs
Fundamental Issues, Computational Models- Data Flow Graph, Control Data Flow Graph, State Machine, Sequential Model, Concurrent Model, Object oriented model, UML	
MODULE 3 Embedded Product Design	10 Hrs
Design and Development of Embedded Product – Firmware Design and Development – Design Approaches, Firmware Development Languages.	
MODULE 4 Embedded Hardware and Firmware	10 Hrs
Integration and Testing of Embedded Hardware and Firmware- Integration of Hardware and Firmware. Embedded System Development Environment – IDEs, Cross Compilers, Disassemblers, Decompilers, Simulators, Emulators and Debuggers.	
MODULE 5 RTOS based Design and Networks	10 Hrs
RTOS based Design – Basic operating system services. Interrupt handling in RTOS environment. Design Principles. Task scheduling models. How to Choose an RTOS. Case Study – MicroC/OS-II. Networks – Distributed Embedded Architectures, Networks for embedded systems, Network based design, Internet enabled systems. Embedded Product Development Life Cycle – Description – Objectives -Phases – Approaches1. Recent Trends in Embedded Computing.	

Text Books:

1. J Staunstrup and Wayne Wolf, Hardware / Software Co-Design: Principles and Practice, PrenticeHall.
2. Jean J. Labrose, Micro C/OS II: The Real Time Kernel, 2e, CRC Press, 2002.

Reference Books:

1. Raj Kamal, Embedded Systems: Architecture, Programming and Design, Third Edition, McGraw Hill Education (India), 2014.
2. Shibu K.V., Introduction to Embedded Systems, McGraw Hill Education (India), 2009.
3. Steave Heath, Embedded System Design, Second Edition, Elsevier.
4. Wayne Wolf, Computers as Components-Principles of Embedded Computer System Design, MorganKaufmann publishers, Third edition, 2012.

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5048					
TITLE OF THE COURSE	FRACTURE MECHANICS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. The course will give much knowledge on fracture mechanics principles, fatigue failure and non-destructive testing and their applications.
2. Test methods and other techniques for fracture study will be discussed
3. The syllabus is designed for students interested in basic building knowledge on mechanics and learns more on engineering materials against crack induced fracture, diagnosis of cause and mechanisms of failure.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Able to possess the analytical tools needed to solve the idealized problem	L2
C02	Be able to use these solutions and make appropriate design against failure analysis	L2
C03	Perform investigation at the crack tip and approximate shape and size of the plastic zone	L3
C04	Analyse the mixed-mode kinds of fracture	L3
C05	Determine the fracture strength using experimental technique	L3

COURSE CONTENT:	
MODULE 1 Background	08 Hrs
Kinds of failure, Modes of fracture failure, Damage tolerance. Energy Release rate- Introduction, Griffith's Dilemma, Surface energy, Definition, Mathematical formulation, Energy release rate of DCB specimen, Crack resistance, Stable and unstable crack growth, R- Curve for brittle Cracks, Critical energy release rate.	

MODULE 2 Mixed mode fracture criteria	10 Hrs
Crack path selection. Interface cracks in layered structures. Anisotropic fracture, linear and nonlinear fracture mechanics, J-Integral Stress Intensity factor- Introduction, Stress and Displacement fields in isotropic elastic materials, Stress Intensity factor –Background for mathematical Analysis, Westergaard approach, Problems	
MODULE 3 SIF of More Complex Cases	10 Hrs
Other applications of Westergaard, Approach, Application of the Finite dimensions, Cracks in a plate of finite dimensions. Edge cracks, embedded cracks, Critical stress intensity factor, Bending and Twisting of Cracked plates.	
MODULE 4 An elastic Deformation at the Crack tip	10 Hrs
Further Investigation at the Crack Tip, Approximate Shape and size of the plastic zone, Effective crack length, Effect of plate thickness, Crack tip opening displacement, problems.	
MODULE 5 Test Methods	10 Hrs
Introduction, -Test Techniques, Test Methods to determine and Determination of Critical CTOD. Fatigue failure- Low cycle and high cycle fatigue, Phase in fatigue life, Safe life and Fail-safe design philosophies, Principles of failure analysis.	

TEXT BOOKS:

1. Ralph I. Stephens, Ali Fatemi, Robert R. Stephens, Henry O. Fuchs, Metal Fatigue in engineering, John Wiley New York, Second edition. 2001.
2. Jack. A. Collins, Failure of Materials in Mechanical Design, John Wiley, New York 1992.
3. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill Education, 2009

REFERENCES :

1. Suresh, S., Fatigue of Materials, Cambridge University press, Cambridge, U.K.1991.
2. Fracture Mechanics, Fundamental and applications, Anderson T L, CRC Press, 2004.
3. Fatigue and Fracture, ASM Hand Book, Vol 19, 2002.

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5049					
TITLE OF THE COURSE	MICRO ELECTRICAL MECHANICAL SYSTEMS (MEMS)					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. To learn dynamics and modelling of micro-systems
2. Understanding design and analysis of micro and Nano system applications
3. Develop experience on microsystems for sensors and actuators applications
4. To learn and characterize technology for MEMS
5. Gain knowledge and have knowledge on state-of-the-art MEMS techniques for Microsystems
6. Have an ability to identify, formulate and solve problems in the field of micro electrical systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Classify the MEMS devices based on its application.	L2
CO2	Demonstrate the working principles of various mechanical sensors and actuators	L2
CO3	Apply the concept of microfluidics in various applications	L3
CO4	Design the various mechanical sensors and actuators	L4
CO5	Identify the suitable fabrication method for a MEMS device	L3
CO6	Choose the appropriate characterization techniques to characterize the MEMS systems.	L3

COURSE CONTENT:

MODULE 1 Introduction	08 Hrs
Micro Electro-Mechanical Systems, Ultra Precision Engineering, Microsensors; Micro-actuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS : MOEMS; Magnetic MEMS; RF MEMS; Micro-fluidic Systems; Bio and Chemo – Devices; MEMS Packages and Design Considerations; Micro Instrumentation.	
MODULE 2 Mechanical Sensors and Actuators	10 Hrs
Principles of Sensing and Actuation; Beam and Cantilever; Micro plates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain Measurement; Pressure measurement; Flow Measurement using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; Shear mode Piezo actuator; Gripping Piezo actuator; Inchworm Technology.	
MODULE 3 Thermal and Fluidic Micro Sensors and Actuators	10 Hrs
Thermal sensors, Electrical Sensors, Chemical and Biosensors Electromagnetic and Thermal micro actuation, Mechanical design of micro actuators, examples, Micro Fluidic systems, Fluid actuation methods, micro valves, micro pumps, and micro motors-Micro actuator systems: Ink-Jet printer heads, Micro-mirror TV Projector.	
MODULE 4 MEMS- Design and Analysis	10 Hrs
Basic concepts of design of MEMS devices and processes, Design for fabrication, Other design considerations, Analysis of MEMS devices, FEM and Multiphysics analysis, Modelling and simulation.	
MODULE 5 MEMS- Characterization	10 Hrs
Technologies for MEMS characterization, Scanning Probe Microscopy (SPM): Atomic Force Microscopy (AFM), Scanning tunnelling microscopy (STM), Magnetic Force Microscopy, Scanning Electron Microscope, Laser Doppler vibrometer, Electronic Speckle Interference Pattern technology (ESPI)	

Text Books:

1. Rai-Choudhury P. MEMS and MOEMS Technology and Applications, PHI Learning Private Limited, 2009.
2. Stephen D. Senturia, Microsystem Design, Springer, 2001
3. Marc Madou, Fundamentals of Microfabrication, Taylor & Francis Group, 2002
4. Gregory Kovacs, Micromachined Transducers Sourcebook, McGraw Hill, 1998

Reference Books:

1. Bao, M.H., Micromechanical Transducers- Pressure sensors, accelerometers, and gyroscopes, Handbook, Elsevier, 2000.
2. Nadim Maluf, An Introduction to Micro electromechanical Systems Engineering, Artech House Publishers, 2000.
3. Stephen D. Senturia, Microsystems Design, Kluwer Academic Publishers, New York, November 2000

SEMESTER	II					
YEAR	I					
COURSE CODE	22MDE5050					
TITLE OF THE COURSE	TRIBOLOGY					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The objectives of the Course are:

1. Understand the steps involved in fundamentals of tribology
2. Able to know how to use the technology to gather and analyze data for bearings applications
3. Identify different types of bearings and lubrication and examine the applications and troubleshoot problems
4. Provide a broad based and discipline mechanism learning concept for tribology

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain basic and fundamental skills for tribological analyses	L3
CO2	Demonstrate the importance of tribology and extending product life of bearings.	L3
CO3	Methodologies of design and troubleshooting tribological and EHL systems	L4
CO4	Use experimental set-up for prediction of tribological behaviour	L3
CO5	Apply mathematical tool such as MATLAB for bearing design	L3

COURSE CONTENT:	
MODULE 1 Introduction to Tribology	08 Hrs
Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems.	
MODULE 2 Hydrostatic Bearings	10 Hrs
Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restrictors, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.	
MODULE 3 Journal Bearings	10 Hrs
Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems.	
MODULE 4 Porous Bearings	10 Hrs
Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages. Antifriction bearings- Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings.	
MODULE 5 Hydrodynamic Lubrications	10 Hrs
Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems, EHL ⁷³ Contacts- Introduction to Elasto – hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution.	

Text Books:

1. Mujamdar. B.C., Introduction to Tribology of Bearing, Wheeler Publishing, New Delhi 2001
2. Radzimovsky, Lubrication of Bearings - Theoretical principles and design The Oxford press Company, 2000.

Reference Books:

1. Dudley D.Fulier., Theory and practice of Lubrication for Engineers, New York Company.1998
2. Moore., Principles and applications of Tribology, Pergamon press, 1975.
3. Pinkus 'O' Stemitch., Theory of Hydrodynamic Lubrication.
4. Stachowiak, G. W, Batchelor, A W., Engineering Tribology, Elsevier publication 1993.
5. Butterworth., Hydrostatic and hybrid bearings, 1983.

SEMESTER III

DEPARTMENTAL ELECTIVES – V

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5051					
TITLE OF THE COURSE	AUTOMOTIVE ELECTRONICS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

1. Obtain an overview of automotive components, subsystems, design cycles, communication protocols and safety systems employed in today's automotive industry.
2. Differentiate electronic and mechanical components used in automobile systems
3. Apply concept of integration of system components
4. Analyse and measure signal conversion parameters
5. Obtain an overview of automotive diagnostics

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand the automotive components, subsystems, design cycles, communication protocols and safety systems	L2
C02	Understand the electronic and mechanical components used in automobile systems	L3
C03	Analyse and measure signal conversion parameters	L3
C04	Apply concept of integration of system components	L3

COURSE CONTENT:	
MODULE 1 Automotive fundamentals overview	08 Hrs
Four stroke cycle, engine control, ignition system, spark plug, spark pulse generation, ignition timing, drive train, transmission, brakes, steering system, starting system. Actuators – fuel metering actuators, fuel injector, ignition actuator, Exhaust After – Treatment System – AIR, catalytic converter, exhaust gas recirculation (EGR), Evaporative emission systems	
MODULE 2 Air/ fuel system	10 Hrs
Air/ fuel system – fuel handling, air intake system, air/ fuel management Sensors: Oxygen (O ₂ /EGO) sensors, throttle position sensor (TPS), engine crankshaft angular position (CKP) sensor, magnetic reluctance position sensor, engine speed sensor, ignition timing sensor, hall effect position sensor, shield field sensor, optical crankshaft position sensor, manifold absolute pressure (MAP) sensor-strain gauge and capacitor capsule, Engine coolant temperature (ECT) sensor, intake air temperature (AIT) sensor, knock sensor, airflow rate sensor, throttle angle sensor.	
MODULE 3 Electronic Engine Control	10 Hrs
Electronic Engine Control – engine parameters, variables, engine performance terms, electronic fuel control system, electronic ignition control, idle speed control, EGR control. Vehicle motion control – cruise control, chassis, power brakes, antilock brake system (ABS), electronic steering control, power steering, traction control, electronically controlled suspension.	
MODULE 4 Communication	10 Hrs
Communication-serial data, communication systems, protection, body and chassis electrical systems, remote keyless entry, GPS Automotive Instrumentation– sampling, measurement & signal conversion of various parameters. Radar warning system, low tire pressure warning system, radio navigation, advance driver information system	
MODULE 5 Automotive diagnostics	10 Hrs
Integrated body- climate control systems, electronic HVAC system, Safety systems- SIR, interior safety, lighting, entertainment systems, Automotive diagnostics – Timing light, engine analyzer, on-board diagnostic off- board diagnostics, expert systems.	

Text Books:

1. Automobile Electrical and Electronic Systems” Tom Denton, Routledge, 5 edition,2017.
2. Understanding automotive electronics, William b. Ribbens,SAMS/Elsevier publishing 6thedition,2002

Reference Books:

1. Automotive electrics automotive electronics systems and components,Robert Bosch Gmbh, john wiley& sons ltd., 5th sedition, 2007

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5052					
TITLE OF THE COURSE	JIGS AND FIXTURES DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

1. Understanding the difference between jigs & fixtures design
2. To understand the construction design of various types of jigs and fixtures
3. To prepare and design of mounting of fixtures on the machine tool and learn more about indexing.
4. Learning the sequence of operations involved in jigs and fixtures.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	More idea on machined components for dimensional stability & functionality	L2
CO2	Design and develop productive and cost effective jigs and fixtures for machines	L3

COURSE CONTENT:

MODULE 1 Introduction	
	08 Hrs
Definition of Jigs and Fixtures, Difference between jigs and fixtures, Advantages, Steps for design. Location Degree of freedom, 3-2-1 principles, Choice of location, redundant location, Diamond pin calculation, Locating methods, Surface location, Rest blocks, pins, V-blocks, Equalizers, Profile locators.	

MODULE 2 Clamping	10 Hrs
Basic principles, cutting forces, Rigid clamping, wedge clamping, Cam clamping, quick action clamps, Toggle clamps, simultaneously acting clamps, Guiding Elements- Jig bushes, Standards, Setting gauges.	
MODULE 3 Indexing Jigs and Fixtures	10 Hrs
Indexing methods, Linear, Rotary, Indexing jigs, Indexing fixtures. Assembly and Welding Fixture – Principles	
MODULE 4 Design of Jigs and Fixture Bodies	10Hrs
Design of Jigs and Fixture Bodies other Elements types of Jigs and Fixtures -Plate jigs, Box jigs, Indexing jigs, Milling fixtures, and Indexing-milling fixtures, turning fixtures, Grinding fixtures, Universal jigs and fixtures, welding fixtures, Broaching fixtures, and Assembly Fixtures.	
MODULE 5 Preparation and Presentation of typical designs	10 Hrs
Drill Jig, Drilling and Reaming Jigs, Milling Fixtures, Turning Fixtures, Indexing Jigs, Indexing Milling, Fixtures	

TEXT BOOKS :

1. Joshi, P .H. Jigs & Fixtures, Tata McGraw Hill Pub. Co. Ltd., 11th print, New Delhi, 1999.
2. Boyes E. William- Michigan, Jigs & Fixtures & Gauges, SME 1st Ed. 1986.

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5053					
TITLE OF THE COURSE	OPTIMIZATION TECHNIQUES					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

The objectives of the Course are:

1. Concentrating on solving complex optimization problems that arise in engineering applications.
2. Direct search methods like Univariate method, Hook and Jeeves' methods.
3. Using the tools like Genetic Algorithms, Simulated Annealing, and Tabu search methods for optimization.
4. Applying the mathematical results, search methods and numerical techniques for optimization using the one dimensional minimization methods.
5. Apply optimization knowledge for minimal cost and minimal weight.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain the Engineering application of optimization, Statement of optimization problem, Classification of optimization problems	L2
CO2	Evaluating the Unimodal function, unrestricted search, Exhaustive search, Dichotomous search	L3
CO3	Evaluating the Direct search methods- Univariate method, Hook and Jeeves' method, Powell's method, Simplex method.	L3
CO4	Explain the Desirable and undesirable effects – functional requirement material and geometrical parameters.	L2
CO5	Analysing the Optimization Techniques by visiting implemented industry.	L5
CO6	Evaluating and conducting a mini project to solve realistic engineering	L3

	problems on Optimization Techniques	

COURSE CONTENT:	
MODULE 1 Engineering application of optimization	08 Hrs
Statement of optimization problem, Classification of optimization problems, single variable optimization, Multivariable optimization with no constraints. Multivariable optimization with equality constraints and inequality constraints, Kuhn - Tucker conditions.	
MODULE 2 One - dimensional minimization methods	10 Hrs
Unimodal function, unrestricted search, Exhaustive search, Dichotomous search, Fibonacci method, Golden section method. Quadratic, Cubic interpolation methods.	
MODULE 3 Direct search methods	10 Hrs
Univariate method, Hook and Jeeves' method, Powell's method, Simplex method. Descent Methods- Steepest descent, Conjugate gradient, Quasi - Newton, Davidon - Fletcher - Powell method.	
MODULE 4 Genetic Algorithms	10 Hrs
Genetic Algorithms - Simulated Annealing - Tabu search methods.	
MODULE 5 Desirable and undesirable effects	10 Hrs
Functional requirement – material and geometrical parameters – Design of simple axial, transverse loaded members for minimum cost and minimum weight.	

Text Books:

1. Rao, S. S., Optimization - Theory and Application, Wiley Eastern, 1979.
2. Deb, K., Optimization for Engineering Design -Algorithms and Examples, Prentice-Hall India,1995

Reference Books:

1. Arora, J. S., Introduction to Optimum Design, Mc Graw-Hill, 1989.
2. Reklaitis, G. V., Ravindran, A. and Ragsdell, K. M., Engineering Optimization- Methods andApplications, Wiley, 1983.

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5054					
TITLE OF THE COURSE	DESIGN OF EXPERIMENTS					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. Introduction of logic, application, and interpretation of various analysis of variance models
2. With up-to-date knowledge on factorial and Taguchi design tools for simulation, analysis, design and control
3. To learn more about response surface design

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understanding the design approach covered in class and their application to fundamental research	L2
CO2	Ability to work independently on design of experiments	L3

COURSE CONTENT:	
MODULE 1 Design of experiments	08 Hrs
Introduction, factor constraints, Interaction terms, Number of runs, enter data, analyze the data, level of factors, Custom designs-Introductions, examples, Screening design creation- Statistical Software introduction, demo using simple case studies.	
MODULE 2 Response surface design	10 Hrs

Introduction, creation, Central Composite Design, Box Behnken design, Contour profile of response surface plot, Design table, analyze the data, using Statistical software simple case study examples- Evolutionary operation, Experiment with random factor-Simple case studies.	
MODULE 3 Factorial Design	10 Hrs
Basic definition, principles and advantages- Creating, Blocking, responses and factors, Simple case studies, 2-level fractional factorial design, Mixture design- Introduction, optimal mixture design, Simplex centroid design- examples, 2k Factorial design, linear Regression analysis error prediction, Full factorial design-Simple Case studies.	
MODULE 4 Taguchi design approach	10 Hrs
Orthogonal array, S/N Ratio, Smaller is better, nominal is better and Larger is better, with simple case studies, analyze the data-Factor effect diagram, Levels	
MODULE 5 Analysis of Variance	10 Hrs
Sum of square - Experimentation with single factor- Determining sample size-Model adequacy checking-Regression approach least square method-Non parametric method- Simple problems.	

TEXT BOOKS:

1. Douglas C Montgomery, Design and analysis of experiments, John Wiley & Sons, Ltd., 5th edition, 2005.
2. Cox. C.R., The Theory of Design of Experiments, Chapman and Hall, 2000.

REFERENCES :

1. JMP. Design of Experiments, SAS Institute Inc., Cary, NC, USA, 2005.

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5055					
TITLE OF THE COURSE	RELIABILITY AND FAILURE ANALYSIS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

1. To understand the course and is planned for those interested in reliability and failure analysis of experiments.
2. To allows and increase efficiency of experimentation, and reveal the essential reliability nature of a process.
3. In particular, risk analysis and techniques are learnt more.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understand the basics of fracture mechanics.	L2
C02	Study the failure caused by corrosion.	L2
C03	Analyse failures by interface reaction and diffusion process.	L3
C04	Determine statistical analysis techniques	L3
C05	Detect how failure are modeled	L3

COURSE CONTENT:	
MODULE 1 - Introduction	08 Hrs
Need and scope of failure analysis and prevention Quality and Reliability, Industry practices of FA and reliability engineering, Common failure types.	

MODULE 2 - Mechanical Fracture, Reaction and Diffusion Induced	10 Hrs
Time Varying Reliability Analysis, NDT for failure analysis, Destructive testing, Fracture mechanics, Fatigue, Delamination. Electromigration, Thermomigration.	
MODULE 3 - Corrosion Induced Failure	10 Hrs
General wear, Galvanic corrosion, Stress Corrosion Cracking. Industrial engineering tools for failure analysis: Fishbone diagram.	
MODULE 4 - Statistical Analysis of Failure	10 Hrs
Basics of statistics, Normal, Weibull and log-normal distribution, Statistical modeling of failure. Industrial engineering tools for failure analysis: Reliability	
MODULE 5 - Examples of failure analysis	10 Hrs
Electromigration in IC devices, fatigue analysis of solder joints for IC package, Case of twin-tower.	

TEXT BOOKS :

1. Modarres, Reliability and Risk analysis, Mara Dekker Inc., 1993
2. New Juran, J.M and Gryna, F.M, Quality Planning and Analysis - Tata Mc Graw Hill publishing Company Ltd. 1982, Delhi, India.

REFERENCES :

1. Halpern, Seigmund, The Assurances Sciences, Prentice Hall International, New Jersey, U.S.A. 1978
2. Blanchard, Bejamin S. Logistics Engineering and Management, Prentice Hall International, New Jersey, U.S.A. 1986.

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5301					
TITLE OF THE COURSE	DISSERTATION PHASE I					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project Hours	Total Hours	Credits
	-	-	-	20	240	10

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. To develop the work practice in students to apply theoretical and practical tools/techniques
2. To improve the professional competency
3. To improve research aptitude by touching the areas which otherwise not covered by theory or laboratory classes.
4. To solve real life problems related to industry and current research.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Solving of real time problems not necessarily new line of enquiry, but shows that student has mastered research and synthesizing skills in producing a contribution to knowledge.	L3
CO2	Builds competency and research aptitude.	L3

COURSE CONTENT:

The thesis shall consist of research work done by the candidate or a comprehensive and critical review of any recent development in the subject of specialization or a detailed report of project work consisting of experimentation/numerical work, design and or development work that the Candidate has executed.

SEMESTER IV

DEPARTMENTAL ELECTIVES –VI

SEMESTER	IV					
YEAR	II					
COURSE CODE	22MDE5056					
TITLE OF THE COURSE	ROBUST DESIGN					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

1. Optimize designs with multiple outputs and variability.
2. Learn design costs and develop branching arrays.
3. Modeling output variation and ranking the contribution to the output variation
4. Estimating the process capability for design variability and inputs.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Understanding typical quality engineering applications.	L2
C02	Plan, design, and conduct experimental investigations effectively for design purpose.	L3
C03	Developing tolerance level and sensitivity for design applications.	L3

COURSE CONTENT:	
MODULE 1 Introduction	08 Hrs

Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions. Steps in robust design - parameter design and tolerance design, Experimental Design: Classical experiments- factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors. 3-level experiment designs for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples.

MODULE 2	10 Hrs

Measures of variability, Concept of confidence level, Statistical distributions - normal, log normal and Weibull distributions. Hypothesis testing, Probability plots, choice of sample size illustration through numerical examples.

MODULE 3	10 Hrs

Measures of variability, Ranking method, column effect method and plotting method, Analysis of variance (ANOVA), in factorial experiments - YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data, illustration through numerical examples.

MODULE 4	10 Hrs

Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs, Column merging method, Branching design, Strategies for constructing orthogonal arrays. Taguchi's inner and outer arrays.

MODULE 5	10 Hrs

Evaluation of sensitivity to noise, Signal to noise ratios for static problems, Smaller – the – better types, Nominal – the – better – type, larger – the- better – type. Signal to noise ratios for dynamic problems, Illustrations through numerical examples. Parameter and tolerance design concepts, Parameter design strategy, Tolerance design strategy, Illustrations through numerical examples.

TEXT BOOKS :

1.	Douglas Montgomery, Design and analysis of experiments, Willey India Pvt. Ltd., V Ed., 2007.
2.	Phillip J. Ross, Techniques for Quality Engineering, 2nd edition. McGraw Hill Int. Ed., 1996.

REFERENCES :

1.	Thomas B. Barker, Quality by Experimental Design, Marcel Dekker Inc ASQC Quality Press, 1985
2.	Jeff Wu, C.F., and Michael Hamada, Experiments planning, analysis and parameter design optimization, John Willey Ed., 2002.
3.	Condra, W.L. and Marcel Dekker, Reliability improvement by Experiments, Marcel Dekker Inc ASQC Quality Press, 1985

SEMESTER	IV					
YEAR	II					
COURSE CODE	22MDE5057					
TITLE OF THE COURSE	FINITE ELEMENT METHODS FOR STRUCTURAL MECHANICS APPLICATIONS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

1. Understand the fundamental ideas of the FEM
2. Prepare a suitable FE model for structural mechanical analysis problems.
3. Understanding of the significance, calculation, interpretation and convergence criteria for structural mechanics.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Have acquired knowledge of finite element analysis linear and nonlinear analysis of structural application problems.	L2
C02	To evaluate and interpret FEA analysis results for structural design and evaluation purposes.	L3

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COURSE CONTENT:	
MODULE 1 - Beam Elements	08 Hrs
Analysis of Beams and Frames, 1-D Beam Element, 2-D Beam Element, 3-D Beam Element, Shear Flexible Beam Elements, Test Problems, practical Applications and computational Problems.	
MODULE 2 - Finite Elements for Plates, Plate Theories	10 Hrs

Classical plate theory, shear deformation theory, improved shear deformation theory. Kirchhoff Plate Elements, Mindlin Plate Elements, Test Problems, Practical Applications and Computational Problems.	
MODULE 3	10 Hrs
Finite Elements or Shells, Flat Shell Elements: Facet Approximation, Curved Shell Elements Isoparametric Shell Elements: Eight- node quadrilateral shell element. Axisymmetric Shell Elements, Practical Applications in Stress analysis of industrial fan impeller, Vibration analysis of a cylinder cantilever shell, Buckling analysis of a blade stiffened panel, Nonlinear behavior of a curved panel , Computational Problems.	
MODULE 4 - Finite Element Analysis Programs	10 Hrs
FEA Program, Organization, Capabilities-Material Models Element library, procedures library, Data processing. FEA Program- A Catalogue, MSc.Nastran, NISA, MARC.LS-DYNA, ANSYS.	
MODULE 5- Advanced Applications	10 Hrs
Nonlinear Finite Element Analysis, Analysis of laminated Composite Structures. Computational Fracture Mechanics, Structural Optimization, Computational Heat Transfer, Computational Fluid Dynamics, Electromagnetic and Coupled- Field analyses, Simulation of Manufacturing Processes.	

TEXT BOOKS :

1. Lakshminarayana, H. V. Finite Element Analysis Procedures in Engineering, Universities Press private Limited, Hyderabad, 2012.

REFERENCES :

1. Tirupathi R. Chandrupatla, Ashok D. Belegundu, Introduction to Finite Elements in Engineering, PHI Learning, 2008.

SEMESTER	IV					
YEAR	II					
COURSE CODE	22MDE5058					
TITLE OF THE COURSE	DESIGN OF MATERIALS HANDLING SYSTEMS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

1. To expose the students with latest material handling system used in industry.
2. To reduce manufacturing cycle time, delays, damage and improve working conditions of the systems
3. Developing tools for robot handling systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
C01	Basics of material handling system.	L2
C02	Various material handling equipment used in industry.	L3
C03	AGV's AS/RS system, conveyor systems.	L2
C04	Application of Robotics in material handling	L3

COURSE CONTENT:	
MODULE 1 - Material Handling	08 Hrs
Functions, Types, analysis, Importance & Scope, Principles, - Part feeding device – types of material handling system – Unit material movement & Unit loads – Receiving, Shipping, in process handling – bulk handling equipment & methods.	
MODULE 2	10 Hrs

Industrial trucks, lifting device, monorails, manipulators, conveyors, storage systems, elevators, racks, bins, pallets, cranes –Automation of material handling – mechanization of part handling.	
MODULE 3 - Types of AGV's	10 Hrs
Guidance techniques – Painted line, wire guided, vision guided method – Applications – Vehicle guidance & routing – Traffic control & safety – system management – Quantitative analysis of AGV system.	
MODULE 4 - Conveyor systems	10 Hrs
Types, Quantitative relationship & analysis – Automated storage system, performance – AS/RS system – Basic components, types, controls, features, applications, Quantitative analysis – carousel storage system – applications.	
MODULE 5- General considerations in robot material handling	10 Hrs
Material transfer application – pick & place operations – machine loading & unloading – characteristics of robot application – Robot cell design – processing, operations – Spot welding, Spray painting, Plastic moulding, forging.	

TEXT BOOKS :

1. Mikell P. Groover, Automated Production system & computer integrated manufacturing -- Prentice Hall of India – 1987.
2. Govindan .K.R, Plant Layout & Material Handling – Anuradha agency – 2001.

REFERENCES :

1. Allegeri, Theodove . H, Material Handling Principle &Practice - C.B.S. Publisher, 1987.
2. Material Handling Equipment for the Manufacturing Industry - AICTE, 1995.

SEMESTER	IV					
YEAR	II					
COURSE CODE	22MDE5059					
TITLE OF THE COURSE	THEORY OF PLASTICITY					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

1. Introduction of plasticity and elasto plastic analysis of systems.
2. System Formulation and solving them

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student shall be able to demonstrate knowledge and understanding on concepts of stress, strain, bending, torsion, vibrations, beams and frames.	L2
CO2	Knowledge of strain problems in practical applications with steady and non-steady case.	L3
CO3	Know the difference between plasticity and elasticity.	L2

COURSE CONTENT:	
MODULE 1 - Stresses and Strains	08 Hrs
Introduction, The Stress–Strain Behaviour, Analysis of Stress, Mohr's Representation of Stress, Analysis of Strain Rate, Concepts of Stress Rate.	
MODULE 2 - Foundations of Plasticity	10 Hrs

The Criterion of Yielding, Strain -Hardening Postulates, The Rule of Plastic Flow, Particular Stress–Strain Relations, The Total Strain Theory, Theorems of Limit Analysis, Uniqueness Theorems, Extremum Principles, Plastic Analysis of Beams and Frames: Introduction, Limit Analysis of Beams, Limit Analysis of Plane Frames, Displacements in Plane Frames, Variable Repeated Loading, Minimum Weight Design, Influence of Axial Forces, Limit Analysis of Space Frames.	
MODULE 3 - Elastoplastic Bending and Torsion	10 Hrs
Plane Strain Compression and Bending, Cylindrical Bars Under Torsion and Tension, Thin-Walled Tubes Under Combined Loading, Pure Bending of Prismatic Beams Under Transverse Loads, Torsion of Prismatic Bars, Torsion of Bars of Variable Diameter, Combined Bending and Twisting of Bars. Advanced Elastoplastic Problems: Expansion of a Thick Spherical Shell, Expansion of a Thick Walled Tube, Thermal Stresses in a Thick-Walled Tube, Thermal Stresses in a Thick Spherical Shell, Pure Bending of a Curved Bar, Rotating Discs and Cylinders, Infinite Plate with a Circular Hole, Yielding Around a Cylindrical Cavity.	
MODULE 4 - Steady Problems in Plane Strain	10 Hrs
Symmetrical Extrusion Through Square Dies, Unsymmetrical and Multihole Extrusion, Sheet Drawing Through Tapered Dies, Extrusion Through Tapered Dies, Extrusion Through Curved Dies, Ideal Die Profiles in Drawing and Extrusion, Limit Analysis of Plane Strain Extrusion, Cold Rolling of Strips, Analysis of Hot Rolling, Mechanics of Machining.	
MODULE 5- Non steady Problems in Plane Strain	10 Hrs
Indentation by a Flat Punch, Indentation by a Rigid Wedge, Compression of a Wedge by a Flat Die, Cylindrical Depression in a Large Block, Compression Between Smooth Platens, Compression Between Rough Platens, Yielding of Notched Bars in Tension, Bending of Single-Notched Bars, Bending of Double-Notched Bars, Bending of Beams and Curved Bars, Large Bending of Wide Sheets.	

TEXT BOOKS :

1. Chakrabarty, J Theory of Plasticity, 3rd ed., 2006, Elsevier.
2. Jacob Lubliner, Plasticity Theory, Revised Edition, 2008.
3. Owen, D. R. J. and Hinton, E. Finite Elements in Plasticity- Theory & Practice, Pineridge Press.

REFERENCES :

1. Hill R, Mathematical theory of plasticity, Oxford, 1998
2. Han W B. Daya Reddy, Plasticity-Mathematical Theory and Numerical Methods, Springer.
3. Maugin, G. A. The Thermo-Mechanics of Plasticity and Fracture, Cambridge University Press.

SEMESTER	IV					
YEAR	II					
COURSE CODE	22MDE5060					
TITLE OF THE COURSE	NON LINEAR ANALYSIS					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	1	-	-	48	4

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES :

1. To introduce linear and nonlinear vibration analysis of systems.
2. Formulation of continuous system problems and solving them.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Student shall be able to demonstrate knowledge and understanding on concepts of degrees of freedom, vibration control, linear and non-linear vibrations.	L2
CO2	Application of non-linear analysis problems in practical applications.	L3

COURSE CONTENT:	
MODULE 1 - Review of one degree of freedom free and forced vibrations	08 Hrs
Introduction, Transient Vibration of single Degree-of freedom systems- Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation.	
MODULE 2 - Vibration Control	10 Hrs
Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, and Vibration dampers. Modal analysis & Condition Monitoring,	

Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis.	
MODULE 3 - Non Linear Vibrations	10 Hrs
Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations.	
MODULE 4 - Random Vibrations	10 Hrs
Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response.	
MODULE 5 - Continuous Systems	10 Hrs
Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.	

TEXT BOOKS :

1. William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, Theory of Vibration with Application, 5th Edition Pearson Education, 2008.
2. Rao, S. S., Mechanical Vibrations, 4th Edition, Pearson Education, 2004.

REFERENCES :

1. Graham Kelly, S., Mechanical Vibrations, Schaum's Outlines, Tata McGraw Hill, 2007.
2. Sujatha, C, Vibrations and Acoustics - Measurements and signal analysis, Tata McGraw Hill, 2009.

SEMESTER	IV					
YEAR	II					
COURSE CODE	22MDE5401					
TITLE OF THE COURSE	DISSERTATION PHASE II					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Project s Hours	Total Hours	Credits
	-	-	-	24	288	12

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

The dissertation demonstrates the student's mastery of relevant resources and methods.

1. An ordered, critical exposition of knowledge gained through student's own effort.
2. Demonstrates sound under-standing of research process.
3. Demonstrates knowledge of appropriate methodology.
4. Demonstrates ability to present study in a disciplined way in scholarly conventions of the discipline.
5. Ability to make critical use of published work.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Improves the professional competency and research.	L3
CO2	Develops the work to apply theoretical and practica tools/techniques.	L3
CO3	Solve problems related to industry and current research.	L3
CO4	Possible publication in journal or conferences.	L3

COURSE CONTENT:
THE REPORT GENERALLY CONTAINS:
1. Cover

2. Title page
3. Certificate(s)
4. Acknowledgements
5. Abstract
6. Contents page
7. List of figures or Tables
8. Introduction
9. Literature survey
10. Methodology
11. Results and Discussion
12. Conclusion and scope of future work.
13. Reference list / Bibliography
14. Appendices.

Avoiding plagiarism

1. Plagiarism is taking the words, theories, or ideas of another person and passing them off as your own.
2. Plagiarism can be copying inadvertently/advertently a passage from a book or journal or pasting something from the internet into report without referencing the original source.
3. Plagiarism can also result from wrong referencing.

Avoiding plagiarism

The guide/supervisor shall certify that the report is checked for plagiarism and is within 25% of the content.

The thesis shall consist of research work done by the candidate or a comprehensive and critical review of any recent development in the subject of specialization or a detailed report of project work consisting of experimentation/numerical work, design and or development work that the candidate has executed. It is expected that students should refer national and international journals, proceedings of national and international seminars. Emphasis should be given to the introduction to the topic, literature review, and scope of the proposed work along with some preliminary work/experimentation carried out on the thesis topic. Student should submit the thesis covering the content discussed above and highlighting the features of work to be carried out in the thesis. Student should follow standard practice of thesis writing. At the end of successfully finishing the work he/she has to submit a detailed report and has to present for a viva-voce.

Open Elective

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5061					
TITLE OF THE COURSE	DIGITAL MARKETING					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. To learn how to do marketing online- Boost website traffic, generate potential leads & increase sales revenue with better brand awareness using internet platforms like Social Media, Email Marketing, Mobile Marketing, Ecommerce Marketing and Affiliate Marketing.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	After completion of the program the students will be able to plan, conceptualize and implement Digital Marketing strategy for client requirements.	L2

COURSE CONTENT:	
MODULE 1 - Digital Marketing Overview	08 Hrs
Introduction, Key terms and concepts, what is marketing? What is digital marketing? Why Digital Marketing wins over traditional Marketing, Understanding marketing strategy, the building blocks of marketing, Understanding Digital Marketing Process: Increasing Visibility, Visitors engagement	
MODULE 2 - Search Engine Optimization and Search Markets	07Hrs

Stakeholders in Search, Customer Insights, On & off-page Optimization, Meta Tags, Layout, Content Updates, Inbound Links & Link Building, Goal Configuration & Funnels, Intelligence Reporting, Conversions, Bounce Rate, Traffic Sources, Scheduling etc.	
MODULE 3 - Social Media	07Hrs
What is Social Media Marketing? Overview of Facebook, Twitter, LinkedIn, Blogging, YouTube and Flickr building brand awareness using social media, social Media Management, Insights and Analytics, Best Practice Examples and case Studies.	
MODULE 4 - Website Analytics	06Hrs
Goal Configuration & Funnels, Intelligence Reporting, Conversions, Bounce Rate, Traffic Sources, Scheduling etc	
MODULE 5 - Email and Mobile Marketing	08Hrs
User Behaviour, Segmentation, Key Metrics, Best Practice Case Studies, Split Testing, Campaign Process Optimisation, SMS Strategy, Mobile Advertising, Mobile Optimized Websites, 7 Step Process for Mobile Apps, Proximity Marketing, Strategic Steps, Review & Testing.	

TEXT BOOKS:

1. Digital Marketing, Vandana Ahuja, Oxford University Press
2. The Art of Digital Marketing: The Definitive Guide to Creating Strategic, Targeted, and Measurable Online Campaigns, Ian Dodson, Wiley 2016

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5062					
TITLE OF THE COURSE	PRODUCT LIFE CYCLE MANAGEMENT					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSE OBJECTIVES:

1. To understand various aspects of Product Life Cycle Management.
2. To understand Digital Manufacturing.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students should be able to use methods, tools and technique taught in the Product Life Cycle Management.	L2

COURSE CONTENT:

COURSE CONTENT:	
MODULE 1 - Introduction to Product Life Cycle Management (PLM)	08Hrs
Definition, PLM Lifecycle model, Threads of PLM, Need for PLM, Opportunities and benefits of PLM, Views, Components and Phases of PLM, PLM feasibility study, PLM visioning. PLM Concepts, Processes and Workflow -Characteristics of PLM, Environment driving PLM, PLM Elements, Drivers of PLM, Conceptualization, Design, Development, Validation, Production, Support of PLM.	
MODULE 2 - Product Data Management (PDM) Process and Workflow	07Hrs
PDM systems and importance, reason for implementing a PDM system, financial justification of PDM implementation. Versioning, check-in and checkout, views, Metadata, Lifecycle, and workflow. Applied problems and solution on PDM processes and workflow.	
MODULE 3 - Tools of Communication for collaborative work	08Hrs
Creation of 3DXML and CAD drawing using CAD software. Creation of an animation for assembly instructions on 3D via composer, creation of an acrobat 3D document. Applied problems and solutions on tools of communication for collaborative work. Collaborative Product Development-Digital mock-up and prototype development, design for environment, virtual testing and validation, marketing collateral	
MODULE 4 - Developing a PLM strategy and conducting a PLM assessment	07Hrs
Strategy, Impact of strategy, implementing a PLM strategy, PLM initiatives to support corporate objectives. Infrastructure assessment, assessment of current systems and applications.	

MODULE 5 - Digital Manufacturing – PLM	06Hrs
Digital manufacturing, benefits manufacturing, manufacturing the first-one, Ramp up, virtual learning curve, manufacturing the rest, production planning.	

TEXT BOOKS:

1. Product Lifecycle Management: Grieves, Michael, McGraw-Hill Edition 200
2. Product Data Management: Burden, Rodger, Resource Pub, 2003

REFERENCES :

1. Fabio Guidice, Guido La Rosa, Product Design for the environment-A lifecycle approach, Taylor and Francis
2. Hartman, Product Lifecycle Management with SAP, 2006
3. Robert J Thomas, NDP: Managing and forecasting for strategic processes

SEMESTER	III					
YEAR	II					
COURSE CODE	22MDE5063					
TITLE OF THE COURSE	PROJECT MANAGEMENT					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	3	-	-	-	36	3

Perquisite Courses (if any)			
#	Sem/Year	Course Code	Title of the Course

COURSEOBJECTIVES:

1. To understand various aspects of project management
2. To understand role of project manager

COURSEOUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students should be able to use project management methods, tools and technique	L2

COURSE CONTENT:	
MODULE 1 - THE PROJECT MANAGEMENT FRAMEWORK -INTRODUCTION	08Hrs
What is a Project? What is project Management? Relationship among Project management, Program management and Portfolio Management, Project Management and Operations Management, Role of a Project Manager.	
MODULE 2 - THE PROJECT MANAGEMENT FRAMEWORK-PROJECT LIFE CYCLE AND ORGANISATION	06Hrs
The project Life Cycle Overview, Project vs. Operational work, Stakeholders, Organizational Influences on Project Management.	
MODULE 3 - THE STANDARD FOR PROJECT MANAGEMENT OF A PROJECT	08Hrs

Project Management Process for a Project: Common Project Management Process Interactions, Project Management Process Groups, Initiating Process Group, Planning Process Group, Executing Process Group, Monitoring and Controlling Process Group, and Closing Process Group.

MODULE 4 - THE PROJECT MANAGEMENT KNOWLEDGE AREAS: PART I	07Hrs

Project Integration management, Project scope management, Project time management, Project cost management, Project quality management

MODULE 5 - THE PROJECT MANAGEMENT KNOWLEDGE AREAS: PART II	07Hrs

Project Human Resource Management, Project Communications Management, Project Risk Management, Project Procurement Management.

TEXT BOOKS:

1. A Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fifth Edition (ENGLISH)

REFERENCES :

1. <http://www.pmi.org/>



SCHOOL OF ENGINEERING

DAYANANDA SAGAR UNIVERSITY

SCHEME AND SYLLABUS

B.Voc (Tool Engineering)

PROGRAMME

2023,2022,2021

BATCH

Academic Year (2023-24)



Definitions/Descrip

Definition of Credit:

1HourLecture (L) Per Week	01 Credit
1HourTutorial(T) Per Week	01 Credit
1HourPractical(P) Per Week	01 Credit
1HourProject(J) Per Week	01 Credit

Course code and Definition:

BSC	Basic Science Courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management Courses
IPCC	Integrated Professional Core Course
PCC	Professional Core Courses
PEC	Professional Elective Courses
OEC	Open Elective Courses
SEC	Skill Enhancement Courses
UHV	Universal Human Value Course
PROJ	Project Work
INT	Internship



Implementation of National Education Policy (NEP) 2020 for the B.Voc Tool engineering students of Batch 2023-24, 2022-23, 2021-22

The implementation of Curriculum follows NEP 2020 and addresses the following features and categories of courses:

1. Student Centric flexible curriculum.
2. Inter-disciplinary Courses,
3. Multi-disciplinary Courses,
4. Ability Enhancement Courses,
5. Skill Enhancement Courses,
6. Value Added Courses,
7. Product Design and Development,
8. Internship(Rural Internship, Industry Internship, Research/Development Internship and
9. Multiple Exit and Multiple Entry



SCHEME 2023-2026 Batch

I SEMESTER (TOOL)													
S.N	Course code	Course Name	Teaching Department	Specific to Department	Teaching Hours/Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	17VT101	English-I	ENG	ENG	02	00	00	00	02	50	50	100	02
2	17VT102	Mathematics-I	MAT	MAT	02	00	00	00	02	50	50	100	02
3	17VT103	Applied Science	BS	BS	02	00	00	00	02	50	50	100	02
4	17VT104	Production Technology-I	ME	ME(TE)	03	00	00	00	03	50	50	100	03
5	17VT105	Quality Management-I	ME	ME(TE)	03	00	00	00	03	50	50	100	03
6	17VT106	Engineering Drawing and CAD-I	ME	ME(TE)	00	00	06	00	06	50	50	100	06
7	17VT108	Quality Management lab-I	ME	ME(TE)	00	00	03	00	03	50	50	100	03
8	17VT109	Work Shop-I	ME	ME(TE)	00	00	07	00	07	50	50	100	07
9	17VT110	English Language Skill Development (ELSD) Lab	ENG	ENG	00	00	02	00	02	50	50	100	02
		Total								450	450	900	30



II SEMESTER (TOOLENGINEERING)

S.N	Course code	Course Name	Teaching Department	Specific to Department	Teaching Hours /Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	17VT201	English-II	ENG	ENG	02	0	0	0	02	50	50	100	02
2	17VT202	Mathematics-II	MAT	MAT	02	0	0	0	02	50	50	100	02
3	17VT203	Production Technology-II	ME	ME	02	0	0	0	02	50	50	100	02
4	17VT204	Basic Electrical & Electronics	ECE	ECE	02	0	0	0	02	50	50	100	02
5	17VT205	Material Technology-I	ME	ME	02	0	0	0	02	50	50	100	02
6	17VT206	Quality Management-II	ME	ME	02	0	0	0	02	50	50	100	02
7	17VT207	Engineering Drawing and CAD-II	ME	ME	00	0	05	0	05	50	50	100	05
8	17VT208	Workshop-II	ME	ME	00	0	08	0	08	50	50	100	08
9	17VT209	Electrical & Electronics lab	ME	ME	00	0	02	0	02	50	50	100	02
10	17VT210	Quality Management lab-II	ME	ME	00	0	03	0	03	50	50	100	03
		Total								500	500	1000	30



DAYANANDA SAGAR UNIVERSITY

III SEMESTER (TOOLENGINEERING)													
S.N	Course Code	Course Name	Teaching Department	Specific to Department	Teaching Hours/Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	17VT301	Production Technology-III	ME	ME	02	0	0	0	02	50	50	100	02
2	17VT302	Material Technology & Heat Treatment	ME	ME	02	0	0	0	02	50	50	100	02
3	17VT303	Strength of Materials-I	ME	ME	02	0	0	0	02	50	50	100	02
4	17VT304	Press Tool Technology-I	ME	ME	02	0	0	0	02	50	50	100	02
5	17VT305	Jigs & Fixtures	ME	ME	02	0	0	0	02	50	50	100	02
6	17VT306	Quality Management-III	ME	ME	02	0	0	0	02	50	50	100	02
7	17VT308	Tool design drawing-I Fusion 360	ME	ME	00	0	06	0	06	50	50	100	06
8	17VT309	Materials laboratory	ME	ME	00	0	04	0	04	50	50	100	04
9	17VT311	Constitution of India and professional Ethics	ME	ME	01	0	0	0	0	50	-	50	00
10	17VT312	Workshop-III	ME	ME	00	0	08	0	08	50	50	100	08
		Total								500	450	950	30



IV SEMESTER (TOOLENGINEERING)													
S.N	Course code	Course Name	Teaching Department	Specific to Department	Teaching Hours /Week				Examination				
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	17VT401	Mould technology	ME	ME	02	0	0	0	02	50	50	100	02
2	17VT402	Production technology-IV	ME	ME	02	0	0	0	02	50	50	100	02
3	17VT403	Strength of Materials-II	ME	ME	02	0	0	0	02	50	50	100	02
4	17VT404	Press Tool Technology-II	ME	ME	02	0	0	0	02	50	50	100	02
5	17VT406	CNC Technology	ME	ME	02	0	0	0	02	50	50	100	02
6	17VT407	Workshop -IV	ME	ME	00	0	06	0	06	50	50	100	06
7	17VT408	Tool design drawing-II Fusion 360	ME	ME	00	0	06	0	06	50	50	100	06
8	17VT412	Design Thinking & Innovation	ME	ME	02	0	0	0	02	50	50	100	02
9	17VT413	Fundamentals of Python Programming lab	ME	ME	00	0	02	0	02	50	50	100	02
10	17VT414	Injection mold and press tool design using CATIA Software	ME	ME	00	0	04	0	04	50	50	100	04
11	17VT411	Kannada Language	ME	ME	01	0	0	0	--	50	--	50	Audit
		Total								550	500	1050	30



V SEMESTER(TOOLENGINEERING)													
S.N	Course code	Course Name	Teaching Department	Specific to Department	Teaching Hours /Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	17VT501	Press Tool Technology-III	ME	ME	02	0	0	0	02	50	50	100	02
2	17VT502	Mould Technology-II	ME	ME	02	0	0	0	02	50	50	100	02
3	17VT503	Production Management control	ME	ME	02	0	0	0	02	50	50	100	02
4	17VT513	Quality Management Systems	ME	ME	02	0	0	0	02	50	50	100	02
5	17VT514	Automation-Pneumatics and Hydraulics	ME	ME	02	0	0	0	02	50	50	100	02
6	17VT507	Workshop Practical-V	ME	ME	00	0	04	0	04	50	50	100	04
7	17VT515	Automation-Pneumatics and Hydraulics Lab	ME	ME	00	0	03	0	03	50	50	100	03
8	17VT516	Project Work-I	ME	ME	00	0	00	05	05	50	50	100	05
9	17VT509	Environmental Science	ME	ME	00	1	0	0	0	50	--	50	Audit
10	17VT517	Introduction to Artificial Intelligence and Machine Learning	ME	ME	02	0	0	0	02	50	50	100	02
11	17VT518	Tool Design Drawing-III	ME	ME	00	0	06	0	06	50	50	100	06
		Total								550	500	1050	30



WISEMESTER(TOOL ENGINEERING)

S.N	Course code	Course Name	Teaching Department	Specific to Department	Teaching Hours /Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	17VT602	Mould Technology-III	ME	ME	02	0	0	0	02	50	50	100	02
2	17VT603	Estimation & Costing	ME	ME	02	0	0	0	02	50	50	100	02
3	17VT604	Industrial Management	ME	ME	02	0	0	0	02	50	50	100	02
4	17VT613	Additive Manufacturing	ME	ME	02	0	0	0	02	50	50	100	02
5	17VT615	Automation- Digital Manufacturing	ME	ME	02	0	0	0	02	50	50	100	02
6	17VT61X	Elective-I	ME	ME	02	0	0	0	02	50	50	100	02
7	17VT606	Tool Design Drawing-IV Fusion 360	ME	ME	00	0	04	0	04	50	50	100	04
8	17VT607	Workshop Practical-VI/3Dprintinglab	ME	ME	00	0	03	0	03	50	50	100	03
9	17VT608	Project work-II	ME	ME	00	0	00	08	08	50	50	100	08
10	17VT614	Automation- Digital Manufacturing-PLC Lab	ME	ME	00	0	03	0	03	50	50	100	03
		Total								500	500	900	30



**SCHOOL OF
ENGINEERING**

DAYANANDA SAGAR UNIVERSITY

PROGRAMELECTIVE-I

SL.NO	COURSECODE	COURSE TITLE	GRO UP
1	17VT616	Non-Destructive Testing	GENERAL
2	17VT617	ProductDesign&Manufacturing	GENERAL
3	17VT618	Advance Mold Technology	GENERAL
4	17VT611	Lean Manufacturing	GENERAL

B.VOC FIRST SEMESTER SYLLABUS

Course code: 17VT101 Total Hours: 30 hrs.	ENGLISH-I	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to enable students : 1. To improve their lexical, grammatical competence. 2. To enhance their communicative skills. 3. To equip students with oral and appropriate 4. written communication skills. 5. To inculcate students with employability and job search skills.				
Course Outcomes	Students after the completion of this course will be able to : 1. Achieve proficiency in English 2. Demonstrate good oral and written 3. communication skills 4. Write resume with reasonable competence				

Module 1

Understanding the alphabet, Middle and last alphabet, Final consonants, Capital & Small letters, Basic punctuation, Reading activity. Articles- 'a', 'an', & 'the', reading activity, writing in patterns, reading activity, Common nouns, Proper nouns, Singular and plural nouns, writing short sentences, Reading activity. Masculine and feminine nouns. Description of simple objects like a note book, a pen, a watch, a switch etc., Pronouns, Reading activity, Adjectives.

05Hrs

Module 2

Vocabulary- simple, Articles and determiners, Information in order, Common noun, Singular and plural noun, Countable and uncountable nouns, Masculine and feminine nouns, Proper nouns. Pronouns. Using word families. Adjectives, Adverbs, Verb- "Be", Prepositions, Questions, Have, Has, Do, Does, Did, Tenses, Making sentences, Connectors.

05Hrs

Module 3

Common noun, Proper noun, Singular and plural, forming plurals. Possessives, Syllables, Hidden words and silent words, Using prefixes and suffixes, Proof reading for spelling errors, Adjectives of numbers- cardinal and ordinal. Action verb, Simple present tense, Simple past tense, Formation of past tense. Questions, Negative sentence, Contractions. Types of sentences. **05Hrs**

Module 4

Common and proper noun, Collective and abstract noun, Possessive noun, Noun numbers, Adjective of quality, Adjective of number, Parts of speech. Infinitives, Tense formation, Active and passive voice, Direct and indirect speech, writing in time, Pick a noun, Using relative pro nouns, Reading activity, Writing activity. Reading activity. Conjunctions, writing activity, Reading activity, Types of adverbs. Comparison of adverbs, short talk, writing activity- writing an autobiography. Degrees of comparison, Reading activity, Auxiliary verb or models. Homophones, The gerund, Transitive and intransitive verbs. Tag questions, Simple conversation, Question answer session **07Hrs**

Module 5

Sentence transformation- simple, compound, complex Common errors in English. Synonyms & Antonyms; one-word substitutions. Communication- definition- basic purpose- types- process Skills in communication- reading skills- guidelines, definition- types, listening skills: definition- essentials for good listening- barriers- difference, between hearing & listening, speaking skills- guidelines for effective oral communication, writing skills- guidelines. Speaking skill- activity, listening skill activity. Business correspondence Layout & form, Types of letters: letter of request, letter of complaint, letter of enquiry. Graphic communication: Definition, types & uses / Interpreting graphs. **08Hrs**

Text Books:

1. English Communication - TTTI Publication
2. A Practical English Grammar - A J Thomson
3. Intermediate English Practice - Pitt. S. Corden
4. Modern Business Letter Writing - J.S Bright
5. English without tears – Bhat

Reference Books:

1. Day. R.A., Scientific English: A Guide for Scientists and Other Professional, 2nd ed. Hyderabad: Universities Press, 2000.

Coursecode:17VT102 Total Hours : 30 hrs	MATHEMATICS-I	L	T	P	C
		2	-	-	2
Course Objectives	The objective of this course is to make the students : 1. Exposed to fundamentals of Mathematics including fractions, Logarithms, Matrices & Determinants 2. Understand concepts of Complex Numbers & Trigonometry and their applications in engineering 3. Understand the basics of differentiation and differential calculus and solve application 4. Apply the concepts of mathematics to engineering problems.				
Course outcomes	Upon successful completion of this course, the trainee will be able to: 1. Analyze and apply mathematical equations 2. Solve mathematically technical problems 3. Apply the concepts of mathematics to engineering problems.				

Module 1

Fundamentals of Mathematics- Fractions-Definition, Types of fractions, Algebra of fractions (Addition, Subtraction, Multiplication and Division), Use of Logarithmic table, Simple problems, Logarithmic laws, Indices and Laws of Indices, Solution of linear equations, Solutions of Quadratic Equations-Factorization, Using formula. **05Hrs**

Module 2

Matrices and determinants-Definition of matrix and its types and matrix algebra, Problems on matrices addition, subtractions and multiplication, Transpose of a Matrix, Definition of determinant and its Evaluation, Properties of determinants.(Without Proof), Minors, Co-factors and Adjoint of a matrix, Inverse of a matrix, Solution of linear simultaneous equations using determinant method (Cramer'sRule). **05Hrs**

Module 3

Complex numbers-Introduction of complex numbers, Representation of complex numbers, Algebra of complex numbers, Polar form of complex numbers, Exponential form of complex, Exercises on polar and exponential forms. **04Hrs**

Module 4

Trigonometry-Defining the trigonometric functions, finding trigonometric values, Values of the trigonometric functions of 30° , 45° , 60° and 90° , Trigonometric functions of any angle and signs of trigonometric functions, Exercises on signs of trigonometric functions, Trigonometric identities, Exercises on trigonometric identities, Compound angles (sum or difference of two angles without proof), Exercises on compound angles, Multiple and Sub-Multiple angles, Exercises on multiple and sub multiple angles, Product formulae (No Problems), Heights and distances, Exercises on heights and distances(Simple Problems), Graphs of Trigonometric functions(Only Sin and Cos). **08Hrs**

Module 5

Differential calculus-Limits definition and evaluation of limits (No derivations), Types of functions (only odd and even functions), Definition of derivative of a function and slope of tangent of the curve, Differentiation of algebraic and exponential functions(Without Proof), Differentiation of trigonometric functions (Without Proof), Differentiation of sum, difference, product quotient of functions, Exercises on derivations of sum, difference, product, quotient of functions, Exercises on derivative of trigonometric functions, Derivatives functions of functions rule, Derivatives of inverse function, Differentiation of parametric equations, Successive differentiation, Application of differentiation-velocity and acceleration. **08Hrs**

TextBooks

1. Technical mathematics - Rice and Knight,Mc-Graw Hill Book he.
2. Applied mathematics for Polytechnics-H.K.Dass

ReferenceBooks

1. Higher Engineering mathematics-B.S.Grewal
2. Higher Secondary Mathematics.

Coursecode:17VT103 Total Hours: 30hrs	APPLIED SCIENCE	L	T	P	C
		2	-	-	2
CourseObjectives	The objective of this course is to make the students understand : 1. Usages of SI units and laws of motion 2. Composition and resolution of forces and condition of equilibrium 3. Understand properties of solids and fluids 4. Understand physics of heat transfer 5. acidic, basic and neutral nature of solutions 6. Basics of Industrial and Organic Chemistry 7. Fundamentals of Modern Physics, Wave motion and Laser technology				
CourseOutcomes	After successful completion of the course, the students should be able to : 1. Understand fundamentals of Force, Motion & Energy and Laws governing them 2. Apply concepts of resolution of forces and Principles of Equilibrium 3. Understand properties of solids & fluid and physics of heat 4. Understand basics of industrial & organic chemistry and their applications 5. Understand fundamentals of Modern Physics, Wave motion and Laser technology				

Module 1

Physical World: Physical quantities, Types of systems of units, Fundamentals and derived quantities, S.I. Units, Dimensions. Force, Motion and Energy: Linear motion, Displacement, velocity, acceleration, Equations of motion, Problems, Newton's law of motion, Momentum, Law of conservation of momentum, Force, inertia, Work, power, energy, Law of conservation of energy, Circular motion, Angular displacement, angular velocity angular acceleration.

06Hrs

Module 2

Composition and resolution of Forces: Definition of composition, resultant, equilibrant, Law of parallelogram of forces, Triangle law of forces, Polygon law of forces. Equilibrium of forces: Introduction, System of forces, Principal of equilibrium, Lamistheorem, Problems, Moments and its applications, Couple. Center of gravity & Moment of Inertia: Introduction, Centroid of plane figures, Methods of finding out center of gravity of plane, Axis of reference, Problems, Center of gravity of solid bodies, Moment of inertia of an irregular plane area. **06Hrs**

Module 3

Properties of solids and fluids: Plasticity, Elasticity, Stress, Strain, Hooke's Law, Young's modulus, Bulk modulus, Rigidity modulus, Surface tension, Capillarity, Viscosity. Heat: Definition of heat, Thermometry, Platinum resistance thermometer, Thermocouple, Pyrometer, Calorimeter, Specific heat capacity, Heat transfer, Expansion of gas. **06Hrs**

Module 4

Theory of Acids and Bases: Introduction, Hydrogen ion Concentration (pH Value) Industrial Chemistry: Corrosion, Types of corrosion, Industrial Water, Disadvantages of using hard water in industry. Organic chemistry: Introduction, Aliphatic hydrocarbons, Aromatic hydrocarbons (Benzene hydrocarbons), Nuclear Fission - Phenomenon of fission with example, Nuclear fusion - Phenomenon of fusion with example. **06Hrs**

Module 5

Modern physics: structure of atom with schematic diagram, radio activity, nuclear fission, nuclear fusion. Wave motion: simple harmonic motion, relation between wave velocity, frequency and wave length, newton's Laplace equation for velocity of sound. Laser: meaning, materials used, types, working principle, application, reflection, refraction, optical fiber, types, working principle, application. **06Hrs**

Text Books:

1. Applied Science (Physics and Chemistry) - TTTI, Madras
2. Applied Mechanics and Strength of Material - R.S. Khurmi
3. Text book of Applied Mechanics – Ramamrutham

Reference Books:

1. Engineering Mechanics (Statics & Dynamics) - Irving H. Shames
2. Engineering Mechanics - S. Timoshenko & Young

CourseCode:17VT104 Total Hours :45 hrs	PRODUCTIONTECHNOLOGY - 1	L	T	P	C
		3	-	-	3
CourseObjectives	The objective of this course is to make the students : 1. Importance of Safety precautions 2. Understand usage of fitting tools 3. Understandtool nomenclature and metal cutting theory 4. Comprehend various drilling operations including counter boring, counter sinking, reaming and tapping 5. Understand various parts of Lathe machine and its basic operations				
Courseoutcomes	Students after the completion of this course will be able to : 1. Explain basic machine tools for various machining operations 2. Understand machining parameters on surface finish, type of operations, production and tool life 3. Interpret type of tools for suitable machining operations based on machining parameters 4. Identify machine tools, operation and other condition for industrial machining components 5. Choose correct manufacturing process for a particular engineering application.				

Module 1

Safety - Causes of accidents: Lack of interest, poor judgment, lack of confidence, lack of knowledge, overconfidence, poor physical fitness, personal problem, improper working environment. General Safety Precautions. **08 hrs**

Module 2

Manual Metal working: Metal working hand tools, devices, specification, types and applications- Work bench, vices, files, hammer, hacksaw, chisels, spanners, screw driver, scrapers. **08hrs**

Module 3

Metal cutting Theory: Metal cutting theory-speed, feed, depth of cut, shear plane Nomenclature of single point cutting tool-significance of positive, negative and zero rake angles different tool angles. **09 hrs**

Module 4

Drilling - Drills: Nomenclature of twist drill- types of drills-material of drill - sharpening of drills - drill size designation - designation drill according to Indian standard system(IS:599). Drilling machines: Different types of drilling machines, specification of a drilling machine, work holding devices, Tool holding devices, drilling machine mechanism, drilling machine operations, drilling time calculation. **10 hrs**

Module 5

Counter boring, counter sinking, reaming and tapping. Counter boring: Importance, Types of counter bores. Reamer: Hand reamer, machine reamer, reaming operation. Taps: Different types of taps, nomenclature of taps, tapping operation. Die:Types of Dies -solid die-split die-die stock-die passing operation. Lathe: Parts of Lathe, Types of lathe, lathe operations. **10hrs**

Text books

- 1.Serope Kalpak Jian; Steven R. Schmid (2010), Manufacturing Engineering and Technology, 6th Edition, Publisher: Prentice Hall, ISBN-10 0-13-608158-1, ISBN- 13 978-0-13-608158-5.
- 2.P.N. Rao. (2009), Manufacturing Technology – Foundry, Forging and Welding, Tata McGraw Hill Publishing Company Ltd., New Delhi.

Reference books

- 1.M P Groover (2007), Fundamentals of Modern manufacturing (materials, processes and systems) third edition, Wiley publications, ISBN-978-0-471-74485-6, USA

Coursecode:17VT105 Total hours: 45	QUALITY MANAGEMENT-I	L	T	P	C
		3	-	-	3
Courseobjectives	The objective of this course is to make the students : 1. Understand terminology in Metrology and usage of measurements in industry 2. Familiarize with different measuring instruments and their working principles 3. Familiarize about marking and marking tools 4. Understand bore/hole measurement techniques 5. Exposed to different types of gauges 6. Use of slip gauges and their applications				
Courseoutcomes	Students after the completion of this course will be able to : 1. Understand the various terms and parameters used in measurements 2. Demonstrate knowledge on different measuring devices & instruments				

Module 1

Introduction to Metrology: Meaning of Metrology - objective of metrology, Importance of inspection in Industry – Quality Control, Units and Measurements – Definitions – Supplementary Units - S.I units The Do's and Don'ts, Precision vs. Accuracy. **10 hrs**

Module 2

Linear Measurements: Steel rules - steel tape, Types of Calipers: types of joints, legs – Transfer calipers –, Principle of Vernier, Vernier - Least count 0.1, 0.5 and 0.02, Vernier caliper- Vernier depth gauge- Vernier height gauge- Gear tooth Vernier, Micrometer – Screw thread micrometer – Dial indicating Micrometer – V anvil micrometer, Error on micrometer. **08 hrs**

Module 3

Marking and Marking Tool: Purpose of marking, Systems of marking: rectangular - polar- Jenny calipers, Tools for marking: surface plate - marking stand - scribe - divider – V-block - angle plate – trammer. Bore measuring instruments: Bore gauge, Telescopic gauge, Hemi-spherical gauge. **10 hrs**

Module 4

Gauges: Classification: According to type - standard and limit, according to purpose - workshop - inspection – reference according to the elements to be checked- gauge for checking holes - shafts - tapers - threads – forms, Plug gauge - snap gauge - taper gauge - thread gauge - profile gauge - radius gauge - feeler gauge - plate and wire gauge, Material for gauge: requirements of good gauge material – HCS case hardened steel) cast steel - plated gauges - Invar - Elinvar - other alloy steels. **10 hrs**

Module 5

Slip gauge: Description of slip gauge - number of blocks in standard sets – wringing property - grades - reference grade - inspection grade - calibration grade - workshop grade, Manufacturing of slip gauges- heat treatment to make wear resistant seasoning to ensure stability- lapping at 200°C. **07 hrs**

Text Books:

1. Beckwith Marangoni and Lienhard, “Mechanical Measurements”, Pearson Education, 6th Edition, 2006.
2. A. K Sawhney, “A course in Mechanical Measurements and Instrumentation”, Dhanpat Rai Publications.
3. Mechanical and Industrial measurements - R.K Jain

Reference books

1. Alan S. Morris, “The Essence of Measurement”, Prentice Hall of India, 1997
2. Beckwith T.G, and N. Lewis Buck, “Mechanical Measurements”, Addison Wesley, 1991
3. Ernest O. Doebelin, “Measurement Systems Applications and Design”, 5th Ed., McGraw Hill Book Co.
4. N. V. Raghavendra and Krishnamurthy, “Engineering Metrology and Measurement”, Oxford University Press.

CourseCode: 17VT106 Total Hours : 90 hrs	ENGINEERING DRAWING AND CAD-I	L	T	P	C
Courseobjective		--	-	06	06
Courseoutcome	The objective of this course is to make the students : 1. Understand the importance of engineering drawing and application of computer. 2. Use engineering drawing instruments competently. 3. Competency to write engineering script. Understand the importance of SP46 standards. 4. Ability to construct & understand standard geometrical shapes. Practice of pictorial projection with example. Practice of orthographic projection with example. 5. Understand the Importance dimensioning in engineering drawing practice with examples. Students after the completion of this course will be able to: 1. Analyze and Design the basic electronic circuits containing semiconductor devices. 2. Identify the need of Integrated Circuits and use the mineralizing circuit applications. 3. Analyze and implement basic Digital Electronic circuits for a given application. 4. Identify the application and significance of electronics in interdisciplinary engineering domains.				

Module -1

Introduction - engineering drawing: Importance of engineering drawing & role of drawing in engineering education, engineering drawing equipment's, Basic drawing instruments T-square, Set Square. Compass, dividers, mini drafter pro-circles, Drawing board & pencil. Introduction to computer aided drafting Importance of computer aided drafting, menu selection, begin new drawing editing existing menu selection practice on computers. Basics of engineering drawing: Features of lettering (Selection of suitable size of letters & numbers as per SP 46). Introduction to CAD. By using screen menu, tool bar & cursor menu, button menu Practice on computer. Exercises: Writing notes in engineering script. Introduction & explanation on utility commands, Help, End, Quit, Save, Limits, Units, function key & Drafting setting practice. Drawing sheet sizes, (as per SP 46). Scale, full scale, reduced scale, Enlarged scale (as per SP 46) lines (As per SP 46). Introduction to entity draw commands Line, absolute, relative, polar co-ordinates, direct distance entry, Points, Undo, redo, and Move. Practice on computers Title block & sheet layout, (As per SP 46)

30 Hrs

Module -2

Dimensioning: Importance of dimensioning, Elements of dimensioning & general rules of dimensioning size of arrowhead, placing of dimension line, projection line, value of dimension & leader lines, System & method of indicating dimensions, Arrangement of dimensions chain dimensioning, parallel dimensioning, superimposed dimensioning, combined dimensioning, superimposed dimensioning & co-ordinate dimensioning, Special indication for dimensions (dimensioning practice). **15 Hrs**

Module -3

Geometric construction: Arc joints, by using compasses, exercises, Line joints. [Circle, arc, polygon ellipse hatch Practice on computers. 1 h for computers], Terminology of different shape, bisecting an angle, bisecting a line, finding a center of given circle & divide a line equal and unequal Conic section Construction of ellipse. Arc intersecting method, understand about parabola & hyperbola, cycloid construction, helix construction & understand about involute, [layers, line type properties modify command erase, copy mirror, offset Practice. **20Hrs**

Module 4

Projection: Introduction about projections. Practice on computers. [Array, rotate, scale, trim, extend, break 2 h for computer] Isometric drawings, steps involved in preparing, construction of circle in isometric view isometric drawings. Practice on computer [chamfer, fillet, stretch, explode 2 h for computer] Exercise on Isometric drawings. From the reference of direct isometric view Practice on computer [edit and display command, isometric snap, object snap, iso plane. **20Hrs**

Module 5

Orthographic projections, planes of projections, first angle projection and third angle projection, why second angle and fourth angle not used in engineering drawing, construction details of front view top view and side view in first angle projection Exercise on orthographic projection. Practice on computer, Exercise on Isometric drawings. From the reference of orthographic view, Identification of view & missing view. **20Hrs**

Note: All the drawing exercises are performed using AutoCAD.

Textbook:

1. Machine drawing - P I Varghese and K.C John
2. SP46 - BIS
3. Engineering Drawing - N.D. Bhatt
4. IS 696 - BIS
5. IS 8000 - BIS

Referencebooks:

1. PSG Hand book - PSG
2. CMTI Hand book

Course code:17VT108 Total Hours: 45 hrs	QUALITY MANAGEMENT LAB-I	L	T	P	C
		00	-	03	3
CourseObjectives	Students after the completion of this course will be able to: 1. Introduce the students to the need, standards and principles of measurement. 2. Introduce the students to the principles of various mechanical elements – such as screws, threads and gears. 3. Provide the students the basics of measurements systems.				
Courseoutcomes	Students after the completion of this course will be able to: 1. The purpose of this course is to provide the student with a basic understanding of the theory and practice of measurement and instrumentation. 2. Recognize the basic elements of common measurement systems. 3. Be able to estimate the accuracy of a measurement, identify possible sources of Measurement errors.				

1. **Calibration of Micrometer** - To calibrate the given micrometer using slip gauge, draw the calibration curve and to evaluate the errors occurred.
2. **Calibration of Vernier caliper and measurement of the given component** - To calibrate and measure the given component by using Vernier caliper.
3. **Measurements using Optical Profile Projector**– To measure the screw thread parameters of a given specimen using Optical Profile projector.
4. **Measurements using Toolmaker's Microscope** -To measure the screw thread parameters of a given specimen using Tool Maker's Microscope.
5. **Measurements of angle using Sine bar** - To determine the unknown angle of the given specimen using sine bar with the help of slip gauge.
6. **Measurements of angle using universal bevel protractor** - To determine the unknown angle of the given specimen using universal bevel protractor.
7. **Measurements of Screw thread parameters using two wire or three-wire methods** - To find the effective diameter of a given screw thread by two or three wire method.

8. **Measurements of surface roughness parameters using mechanical comparator** - To measure the various surface roughness parameters of the components using mechanical comparator (dial gauge indicator)
9. **Measurements of gear tooth profile using gear tooth Vernier caliper** - To Measure the tooth thickness of the given gear using Gear Tooth Vernier Caliper.

Text Books:

DSU Metrology Manual

Course Code:17VT109 Total Hours: 105	WORK SHOP-1	L	T	P	C
		00	--	07	07
Course objective	The objective of this course is to make the students : 1. Aware of safety aspects in handling of fitting tools and equipment and create different fitting joints 2. Fabricate various metal joining process including soldering, brazing and welding joints 3. Learn basics of development and create sheet metal models				
Course outcome	Students after the completion of this course will be able to : 1. Demonstrate fitting skills and create fitting joints 2. Exhibit welding, soldering & brazing skills and create models				

1. Fitting: Study of fitting tools, carry out fitting work of models involving rectangular, Triangular, semi-circular and dovetail joints.
2. Welding: Study the joining process (Welding) and carry out Welding exercises of Butt joint, Lap joint, T joint and L-joint.
3. Sheet Metal: Fabricate simple shapes using sheet metal.
4. To Perform Various Operations on a Lathe Machine
5. To Perform Various Operations on a Drilling Machine

Text Books:

1. DSU Work shop manual.

Course code:17VT110 Total Hours: 30 hrs	English Language Skill Development -LAB	L	T	P	C
			-	02	02
Course Objectives	The objective of this course is to enable students : WHY study Spoken English? Responding to Requests and asking Asking for Clarifications, Inviting, Expressing Sympathy, Congratulating Letters and Sounds Practice work. Practice Pronunciation				
Course Outcomes	Spoken English with letter, sounds, and proper pronunciation.				

Practice 1:

1. WHY study Spoken English?
2. Making Inquiries on the phone, thanking and responding to Thanks Practice work.

Practice 2:

1. Responding to Requests and asking for Directions Practice work.

Practice 3:

1. Asking for Clarifications, Inviting, Expressing Sympathy, Congratulating
2. Apologizing, Advising, Suggesting, Agreeing and Disagreeing, Practice work.
3. The Sounds of English Practice work.

Practice 4:

1. Letters and Sounds Practice work. Practice:
2. The Sounds of English Practice work.

Practice 5:

1. Pronunciation
2. Stress and Intonation Practice work.

B.VOC SECOND SEMESTER SYLLABUS

Coursecode:17VT201 Total Hours: 30 Hrs	English-II	L	T	P	C
		02	-	-	02
CourseObjectives	The objective of this course is to enable students : 1. To improve their lexical, grammatical competence. 2. To enhance their communicative skills. 3. To equip students with oral and appropriate written communication skills. 4. To inculcate students with employability and job search skills.				
CourseOutcomes	Students after the completion of this course will be able to : 1. Achieve proficiency in English 2. Demonstrate good oral and written communication skills 3. Write resume with reasonable competence				

Module 1

Business correspondence 2: Documents for internal communication, internal note, Memorandum- Format Incident report (Theft, internal clash, facility problems) **05Hrs**

Module 2

Business correspondence 3: Technical writing: Importance and types of formal report. Layout of a technical report. Procedure of writing a report. Business correspondence 4, Meeting and its documentation, Notice and agenda, Minutes of meeting **06Hrs**

Module 3

Writing activity, Description: Physical description. Writing a set of instructions: *for any of your labs/ work shop/ equipment/machines. To ride a bike/to make a cup of tea/ an omelette/to bake a cake, etc. **06Hrs**

Module 4

Public Speaking, Shop talk. Oral presentation of technical information Stages: Topic selection planning- collection of information-outlining-developing the technical content- attaching introduction and conclusion –practice-rehearsal and feedback, Presentation skills: Personal appearance- posture- gesture-voice speed – language- pauses- eye contact- visual aids- articulation time Management. **06Hrs**

Module 5

Recruitment Process, Resume and cover letter, Job interview-tips to face interviews successfully, Mock interview. Group discussion: Rules –do's and don'ts – qualities to be observed in candidates. GD- practice sessions **07Hrs**

Text Books:

1. Dhanavel.S.P. English and Communication Skills for Students of Science and Engineering, Orient Black swanLtd.,2009.
2. MeenakshiRaman and SangeethaSharma. Technical Communication-Principles and Practice, Oxford UniversityPress,2009.

Reference Books:

1. Day.RA., Scientific English: A Guide for Scientists and Other Professional, 2nded. Hyderabad: Universities Press,2000.
2. Intermediate English Practice - Pitt. S. Corden

Coursecode:17VT202 Total Hours : 30	MATHEMATICS-II	L	T	P	C
		2	-	-	2
CourseObjectives	The objective of this course is to make the students : 1. Exposed to fundamentals of Mathematics including fractions, Logarithms, Matrices & Determinants 2. Understand concepts of Complex Numbers & Trigonometry and their applications in engineering 3. Understand the basics of differentiation and differential calculus and solve application 4. Apply the concepts of mathematics to engineering problems.				
Courseoutcomes	Upon successful completion of this course, the trainee will be able to: 1. Analyze and apply mathematical equations 2. Solve mathematically technical problems 3. Apply the concepts of mathematics to engineering problems.				

Module 1

Percentage, Ratios and Proportions: Simple Problems (like if percentage is given find the number and vice versa)

03Hrs

Module 2:

Analytical Geometry: Area and perimeter of triangle, Areas and perimeter of Rectangle. Area and perimeter of Square, Area and perimeter of Parallelogram, Area and perimeter of Rhombus, Area and perimeter of Trapezium, Area and perimeter of Circle, Length of an arc, Area of sector (Direct Problems), Cartesian Co-Ordinates, Equation of axis, Distance formula, Section formula & midpoint, (Direct Problems), Definition of Centroid of Triangle (Direct Problems). Slope: Definition, finding slope of straight line, Condition for Perpendicularity and parallelism (Simple Problems). Equation of straight line. Circle- Definition, Standard form, General Equation of a circle to find centre and radius. **10 Hrs**

Module 3:

3D Shapes: T.S.A, L.S.A and Volume of Cylinder, T.S.A, L.S.A and Volume of Cube, Cuboid, T.S.A, L.S.A and Volume of Cone, T.S.A, L.S.A and Volume of Sphere, T.S.A, L.S.A and Volume of Hemi-Sphere, T.S.A and Volume of Pipe **05Hrs**

Module 4:

Integral calculus and differential equations: Define Integrals of function and standard formulae of trigonometric functions, Problems using standard formulae. Integration by parts. Definite Integral and evaluation of definite integrals and simple problems. Area under plane curves – simple problems. Define differential equations with example. Define order and degree of differential equations. Solve differential equations of the type

a) $ad^2y/dx^2 + b dy/dx + cy = 0$ b) $ad^2y/dx^2 + b dy/dx + cy = e^{mx}$ **07Hrs**

Module 5:

Statistics, Mean, Median and Mode (Raw Data), Range and Standard Deviation. Problems on above methods. **05Hrs**

TextBooks

3. Technical mathematics - Rice and Knight, Mc-Graw Hill Book he.
4. Applied mathematics for Polytechnics-H.K.Dass

Reference Books

3. Higher Engineering mathematics-B.S.Grewal
4. Higher Secondary Mathematics.

Coursecode:17VT203 Total hours: 30hrs	PRODUCTION TECHNOLOGY – II	L	T	P	C
		02	--	--	02
Courseobjectives	The objective of this course is to make the students understand : 1. Manufacturing processes including casting, forging and rolling 2. Material removal processes including turning, drilling, milling & grinding 3. Non-conventional machining processes and their applications				
Courseoutcomes	After successful completion of the course, the students should be able to : 1. Comprehend the various machining processes such as turning, drilling, milling and grinding. 2. Understand the principle of non-traditional machining processes. 3. Identify and suggest correct manufacturing process for particular application.				

Module 1

Lathe:Boring, Feed mechanism, feed gear box, Thread cutting mechanism and thread cutting operation, Taper and Taper turning, Taper turning method. **02Hrs**

Module 2

Cutting Tool Material: Characteristics of ideal cutting tool material, cutting tool material. **02Hrs**

Module 3

Cutting fluids and lubricants:Properties of good cutting fluid, Types of cutting fluids, Properties of lubricants, Classification of lubricants. **02Hrs**

Module 4

Milling:Classification of milling machines, Parts of milling machines, milling process, milling cutters, Nomenclature of milling cutter, cutting speed, feed and depth of cut, Work holding devices, cutter holding devices.Grinding:Grinding operations, Grinding machines, surface grinders, cylindrical grinders, Tool and cutter grinder.Permanent fastening methods: Welding, Soldering, Brazing, Rivet joints **06Hrs**

Module 5

Basic health and safety: Health and safety, Protective clothing/Equipment, Hazards, Safe working practices, Methods of accident prevention, Good housekeeping practices at various areas. Fire safety, Types of fires, Rescue techniques applied during fire hazard, Proper housekeeping in order to prevent fire hazards, Correct use of a fire extinguisher. Emergencies, rescue and first-aid procedures, Appropriate first aid to victims were required eg. in case of bleeding, burns, choking, electric shock, poisoning etc. **08Hrs**

Module 6

Working Effectively with others at work: Accurately receive information and pass on information to authorized persons who require it and within agreed timescale and confirm its receipt, display appropriate communication etiquette while working. Demonstrate responsible and disciplined behaviors at the workplace. Escalate grievances and problems to appropriate authority as per procedure to resolve them and avoid conflict **06Hrs**

Module 7

Metal casting process: Sand Casting : Sand Mould – Type of patterns - Pattern Materials – Pattern allowances – Moulding sand Properties and testing – Cores – Types and applications – Moulding machines– Types and applications; Melting furnaces : Blast and Cupola Furnaces; Defects in Sand casting. **04Hrs**

Text Books:

1. Kalpak Jain, Manufacturing Engineering & Technology, Addison Wesley, 1997
2. Poul De Garmo, J.T. Black, R.A. Kosher, Materials and Processes in Manufacturing, Prentice Hall of India, 1997.
3. Production Technology - Jain, Agarwal

Reference Book:

1. R.K. Jain, Production Technology, Khanna Publishers, 2001
2. R.K. Gupta, Production Technology, Sathya Prakashan, 2010

Coursecode:17VT204 Total Hours : 30 hrs	BASIC ELECTRICAL & ELECTRONICS	L	T	P	C
		02	-	-	02
CourseObjectives	The objective of this course is to make the students understand : 1. The importance of basic principles of electrical electronics for industrial application. 2. Electrical and Electronic measuring instruments and their usage 3. Working principles of Electrical motors				
Courseoutcomes	Students after the completion of this course will be able to : 1. Learn basic concepts and working of electrical devices. 2. Apply the electronic and electrical measuring instruments for practical applications.				

Module 1

Electrical Safety -Electrical safety, Important of Earthing, Electric shock, First aid for electric shock, Precautions against shock, Cause of accidents and their preventive measures, Electronic Materials and Components- Conductors, Semiconductors and Insulators, Properties and Applications, Resistors, Capacitors, Inductors- Specifications and Applications, Diodes, Transistors and ICs- Specifications and applications. **06 Hrs**

Module 2

Cables and Wires- Types, Specifications and Applications, Care to be taken while connecting cables / wire to terminals of motors, switches, Color coding of cables and wires- Phase, Neutral, Earth. Measuring instruments- Ammeter, Voltmeter, CRO, Multimeter. **04 Hrs**

Module 3

DC & AC Circuits- Definitions- Electric current, Voltage and Resistance, Ohm's Law and Kirchhoff's Laws, Resistance in series, parallel, Simple problems. Fundamental of AC Voltage and current, Peak, Average, RMS value, of sine wave, Frequency, Time period, Amplitude, Power, Power Factor, Single Phase / Three Phase connections, Delta, connections, Relationship between phase and line voltages, Current in star and Delta connections. Electrical Protective Devices- Different types of switches, Fuses and their applications, MCB – Specification, Application, ELCB / RCCB- specification, Applications. **06Hrs**

Module 4

Rectifiers and Power supply- Rectifiers, Types and applications, Regulated Power supply.
DISPLAY DEVICES- Application of LED, LCD. **07Hrs**

Module 5

Sensors- Types, Applications.AC Machines- Transformer, Types of transformers (current and Voltage), Principle of operation of transformers, Applications of transformer, Single phase induction motor- Working principle, Applications, Three Phase induction motor, Working principle, Control Elements, Applications. DC Machines- DC Generator & DC Motor, Construction, Principle of operation, Types and Applications. **07Hrs**

Text Books

1. Electrical Technology - B.L Theraja
2. Electrical Engineering Theory - K Mehta
3. Basic Electrical and Electronics - B L Theraja

Reference Books

1. Electrical Technology - H Cotton
2. Principles of Electrical & Electronics - V .K Metha

CourseCode:17VT205 Total Hours :30hrs	MATERIALTECHNOLOGY-I	L	T	P	C
		02	-	-	02
CourseObjectives	The objective of this course is to make the students understand 1. Mechanical behavior of engineering materials and their applications. 2. Atomic and molecular structures of engineering materials. 3. Mechanical properties of Ferrous & Non-Ferrous metals & alloys. 4. Various destructive & non-destructive testing methods.				
Courseoutcomes	Students after the completion of this course will be able to : 1. Understand basic structure and terminology associated with engineering materials. 2. Perform calculations to qualify materials properties and characteristics. 3. Select the right materials for engineering process and application.				

Module 1

Scope of Material Technology- Historical perspective: Role of engineering material, Classification:- List and the different types of ferrous metals, pig iron, cast iron, wrought iron, steel. Metals and non-metals, Ferrous and non-ferrous, Properties of materials: Physical properties, Chemical properties, Magnetic properties, Mechanical properties.

05 Hrs

Module 2

Ferrous metals- Introduction to manufacturing process, types, properties and application of the following- Pig iron, wrought iron, Cast iron- grey, white, Steel-carbon steel, low, medium and high alloy steel, Influence of following elements on the properties of steel- Carbon, Silicon, Phosphorous, Sulphur, Manganese.

05 Hrs

Module 3

Alloy Steel- Introduction, Alloying elements and their effect on properties of steel, Chromium, Nickel, Vanadium, Tungsten, Molybdenum, Cobalt, Super alloys: Titanium based and Inconel. Materials used for manufacturing cutting tools, their properties and applications - Alloy steels, HSS, uncoated carbide, carbide, cermet, Ceramics, CBN(Cubic Boron Nitride) Poly Crystalline Diamond.

05Hrs

Module 4

Materials used in tooling- specification, composition, properties. Materials used in Jigs and fixtures, Press tools, Moulds, Die casting dies, Forging dies. Non-Ferrous metals- Properties and application of: Copper and its alloys, Aluminum and its alloys, Zinc, Tin, Magnesium. **05Hrs**

Module 5

Testing of Material: Introduction, Destructive and non-destructive tests, Destructive tests, q Tensile test, Compressive test, Impact test, Nondestructive test- Visual, liquid penetration, magnetic particle, ultrasonic, radiographic Hardness testing- Rockwell, Brinell&Vickers. **05Hrs**

Module 6

Non-metallic materials :Polymers – types of polymer, commodity and engineering polymers – Properties and applications of various thermosetting and thermoplastic polymers (PC, ABS, PA, PVC – Urea and Phenol formaldehyde) **05Hrs**

Text books

1. William D. Callister, Jr., “Materials Science and Engineering an Introduction”, 2nd Edition, John Wiley & Sons, Inc., 2007.
2. V. Raghavan, “Materials Science and Engineering”, Prentice – Hall of India Pvt. Ltd., 2007

Reference books

1. J.M. Shackelford, Introduction to Materials Science for Engineers, 5th Edition, Prentice-Hall, Inc. 2000.
2. Suryanarayana, A. V. K., “Testing of Metallic Materials”, Prentice Hall India, New Delhi, 1979.
3. W. Bolton, “Engineering materials technology”, 3rd Edition, Butterworth & Heinemann, 2001.
4. William F. Smith, “Structure and Properties of Engineering Alloys”, Mc-Graw-Hill Inc.,

Coursecode:17VT206 Total hours: 30		QUALITY MANAGEMENT -II	L	T	P	C
			2	--	--	2
Courseobjectives	The objective of this course is to make the students : 1. Understand terminology in Metrology and usage of measurements in industry 2. Familiarize with different measuring instruments and their working principles 3. Familiarize about marking and marking tools 4. Understand bore/hole measurement techniques 5. Exposed to different types of gauges 6. Use of slip gauges and their applications					
Courseoutcomes	Students after the completion of this course will be able to : 1. Understand the various terms and parameters used in measurements. 2. Demonstrate knowledge on different measuring devices & instruments					

Module 1

Limits, Fits and Engineering tolerances: Limit systems – advantages, Interchangeability, Elements of limit system: nominal size - basic size actual size -allowance - limits - upper - lower - tolerance - unilateral – bilateral ,Fit: hole and shaft: Types of Fits: clearance - interference – transition, I.S.919 - 25 Fundamental deviation - 8 Tolerance grades - symbols -numeral - letter - terminology - zero line - deviation - upper –lower, Symbols for tolerance deviation and fit - hole basis and shaft basis system - practice problems - guidelines for selection of fits. Selective assembly

08Hrs

Module 2

Taper and angular measurement & measuring tools: Definition of taper - taper elements, Specification of taper – conicity, Standard tapers - morse – metric, Measurement of angle - universal bevel protractor - parts of bevel protractor - construction of vernier scale - least count. Method of checking – problems, Sine plate - construction – use Sine centre – use , Spirit level - principle - construction , Angle gauges - use - number of gauge blocks in standard set addition and subtraction of angles – problems

08Hrs

Module 3

Comparators: What is a comparator - classification based on method of magnification? Advantages and disadvantages, Mechanical comparator – Dial type & universal- working.

04Hrs

Module 4:

Measuring machines: Toolmaker's Microscope – parts – protractor eye piece – radius measuring head – thread template unit, projection attachment – applications. Profile Projector.

Co-ordinate Measuring Machine – XYZ co-ordinates. **05Hrs**

Module 5.

Measurement of Power and Flow: Measurement of power, flow and temperature Force, torque, power - mechanical, Pneumatic, Hydraulic and Electrical type. Flow measurement: Venturi meter, Orifice meter, rotameter, pitot tube – Temperature: bimetallic strip, thermocouples, electrical resistance thermometer – Reliability and Calibration – Readability and Reliability. Vibration's measurement, frequency, displacement, velocity & acceleration, Modes of heat transfer, Fourier Law of heat conduction, thermal conductivity, temperature distribution in composite wall **05Hrs**

Text Books:

1. Beckwith Marangoni and Lienhard, "Mechanical Measurements", Pearson Education, 6th Edition, 2006.
2. A. K Sawhney, "A course in Mechanical Measurements and Instrumentation", Dhanpat Rai Publications.

Reference books

1. Alan S. Morris, "The Essence of Measurement", Prentice Hall of India, 1997
2. Beckwith T.G, and N. Lewis Buck, "Mechanical Measurements", Addison Wesley, 1991
3. Ernest O. Doebelin, "Measurement Systems Applications and Design", 5th Ed., McGraw Hill Book Co.
4. N. V. Raghavendra and Krishnamurthy, "Engineering Metrology and Measurement", Oxford University Press.

Course Code:17VT207 Total Hours : 75hrs	ENGINEERING DRAWING AND CAD-II	L	T	P	C
		-	-	05	05
Course objective	The objective of this course is to make students : 1. Understand the principles and requirements of machine & production drawings 2. Understand and interpret drawings of machine components so as to prepare assembly drawings using standard CAD packages 3. Develop the technical skills necessary to generate an engineering drawing and an engineering assembly using a modern CAD system 4. Learn how to assemble and disassemble important parts used in major mechanical engineering applications.				
Course outcome	Students after the completion of this course will be able to : 1. Create drawings of Bolted, Riveted & Welded joints and Couplings 2. 3D (Solid) models of engineering components, sub-assemblies & assemblies and generate detailed drawings using a CAD system				

Module 1:Dimensions and Tolerances

Classifications of dimensions- functional, nonfunctional, auxiliary, and features, IS specified tolerance. - Indian standard/ISO system of limits and fits (IS919, ISO 286), Fits.- clearance fit , transition and interference fit. General tolerance. – IS 2102{part1 and part2}. Exercise for general tolerance. **15Hrs**

Module 2: Sectioning and Surface structure

Introduction about sectioning, Classification of section views- Full section, half section, local section, revolved section, removed section, offset section, auxiliary section, and aligned section, General rules of sectioning. - hatching of single object, adjacent object, thin material, large area, rib & web section, Conventional representation for hatching,cutting plane line,Exercise. Introduction, - Types of surface texture, nomenclature of surface texture, Indication of surface roughness, Symbols of specifying the direction of lay, Example. **15hrs**

Module 3: Permanent Fastenings

Riveted Joints: Single and double riveted lap joints, butt joints with single/double cover straps (Chain and Zigzag, using snap head rivets) Common types of joints, terminology, proportions and representation; Welds: Types of welds and welded joints, edge preparation, specifications, and representation of welds on drawings. **15Hrs**

Module 4: Screwed Fasteners

Introduction, Screw thread nomenclature. - Major dia, minor dia, pitch, lead, flank, crest, root, thread angle etc.... Forms of thread- metric thread, V thread, BSW thread, Buttress thread, Square thread, ACME thread, and worm thread, Single and multi-start thread, Thread specification, Conventional representation of threads, Different types of bolt and threads. – Bolt, nut, set screws, locking screws, lock nuts, Socket head cap screw and CSK screw and assembly. **16Hrs**

Module 5: Geometrical Tolerance

Introduction about geometrical tolerance, Tolerance frame and features, Indication of features of control, Datum. - Primary, secondary and tertiary datum, Exercise **14Hrs**

Module 6: Assembly and detailed drawing

Introduction about assembly and part drawing, Assembly drawing, Detailed drawing, Exercise. – tap wrench, U clamp with V block, assembly fit, C-clamp, Tool makers clamp & Guide plate tool. **14Hrs**

Text books

1. N.D. Bhat & V.M. Panchal 'Machine Drawing'
2. French, T. E., Vierch, C. J., and Foster, R. J., Engineering Drawing and Graphic Technology, 14th Ed., McGraw-Hill, 1993

Reference books

1. S. Trymbaka Murthy, 'A Text Book of Computer Aided Machine Drawing', CBS Publishers, New Delhi, 2007
2. K.R. Gopala Krishna 'Machine Drawing', Subhash Publication.
3. Narayana K.L., Kannaiah, P., and Venkata Reddy K, Machine Drawing, 3rd Ed., New Age International Publishers, 2006.

CourseCode:17VT208 Total Hours: 120	WORK SHOP - II	L	T	P	C
		-	-	08	08
Courseobjective	The objective of this course is to make the student aware of : 1. The basic fundamentals and mechanics of metal cutting, tool geometry, tool life and tool wear 2. Knowledge on tool materials, tool life, tool wear, effect of lubrications and coolant used in machining operation. 3. The basic knowledge of various machine tools, classification, specification, operations of each machining processes like turning, milling, shaping, final finishing operations.				
Courseoutcome	Students after the completion of this course will be able to : 1. Understand the mechanics of metal cutting operations, various tool materials, parameters affecting machining operations like feed, speed, coolant, tool life, tool wear, and temperature 2. Apply knowledge of machining processes to select parameters and carry out machining for various practical applications				

LIST OF EXPERIMENTS

1. Introduction of General-Purpose Machines.
2. Study of Single Point Cutting Tool and Multi Point Cutting Tool.
3. To Study of Mechanism in Lathe and Perform Various Operations on a Lathe Machine.
4. To Study Construction, Working and Performing Operations on a Drilling Machine
5. To Study Construction and Working of Milling Machine.
6. To Study Construction, Working and Perform Grinding Operation on a Grinding Machine.
7. Introduction of Computer Numerical Control Machines and Demonstration of Few Work Pieces Jobs.
8. Use of foundry tools and other equipment, preparation of moulds using two moulding boxes with or without patterns. (Split pattern, Match plate pattern and Core boxes).
9. Preparation of one casting (Aluminum or cast iron-demonstration only)
10. Forging Exercises

Course code:17VT209 Total Hours: 30hrs	ELECTRICAL& ELECTRONICS LAB	L	T	P	C
		-	-	02	02
Course Objectives	The objective of this course is to make students : 1. Expose to overall exposure to basic Electrical & Electronics Components and Devices. 2. Analyze Ohm's, Kirchhoff laws 3. Understand the different motor's operation and principle				
Course outcomes	Students shall be able to 1.Demonstrate the basic skill to operate electrical and electronic equipment's and devices. 2.To develop the knowledge on constructing basic electronic and electrical circuits.				

LIST OF EXPERIMENTS

1. Forming mesh and soldering exercises using 22SWG tin coated copper wire
 3. Forming resistors and soldering them on to a groove board and PCB
 4. Tinning multi strand copper wire, forming, assembling and soldering electronic components on PCB, and re-soldering Practice
 5. Extension of ammeter range
 6. Conversion of DC ammeter to DC voltmeter
 7. Charging and discharging curves of a capacitor
 8. **Introduction to lab safety,procedure,SS,rules and regulations**
 9. Familiarization of Tool kit, and basics of bread board connections, CRO, MULTIMETER, power supply
 10. Ohm's law
 11. Kirchhoff s current and voltage law
 12. VI characteristics of diode
 13. Rectifier –Half wave and full wave rectifier.
 14. Clipper and clamper circuits.
 15. A C and D C Motors
- Self-study exercise.

Text Books

1. Electrical Technology - B.L Theraja
2. Electrical Engineering Theory - K Mehta

Course code:17VT210 Total Hours: 45hrs	QUALITY MANAGEMENT LAB- II	L	T	P	C
		--	-	03	03
Course Objectives	Students after the completion of this course will be able to: 1. Introduce the students to the need, standards and principles of measurement. 2. Introduce the students to the principles of various mechanical elements – such as screws, threads and gears. 3. Provide the students the basics of measurements systems.				
Course outcomes	Students after the completion of this course will be able to: 1. The purpose of this course is to provide the student with a basic understanding of the theory and practice of measurement and instrumentation. 2. Recognize the basic elements of common measurement systems. 3. Be able to estimate the accuracy of a measurement, identify possible sources of Measurement errors.				

1. To study the vibration measurement, frequency, displacement, velocity & acceleration.
2. Calculation of the Rate of Flow Using Rotameter-To calibrate rotameter at different flow rates with actual discharge
3. Determination of flow rate through Orifice Meter –and also to determine the co-efficient of discharge for orifice meter at different flow rates.
4. Determination of flow rate through of the Given Venturi meter and also determine the coefficient of discharge for venturi meter at different flow rates.
5. Determination of thermal conductivity of metal rod
6. Determination of thermal conductivity of composite wall

B.VOC THIRD SEMESTER SYLLABUS

Course code: 17VT301 Total Hours: 30 hrs	PRODUCTION TECHNOLOGY -III				L 02	T -	P -	C 02
Course Objectives	The objective of this course is to enable students : 1. Awareness of advanced milling 2. Awareness of advanced grinding 3. Familiarization of broaching 4. Highlights of jig grinding and jig boring 5. Awareness of super-finishing process 6. Familiarization of electric discharge machining. 7. Awareness of manufacturing process.							
Course Outcomes	Students after the completion of this course will be able to : 1. Explain the various machining processes such as turning, drilling, milling and grinding. 2. Analyze the various manufacturing processes such as casting, hot working and cold working. 3. Explain the processing of different materials such as ceramics and glass.							

Module 1

Milling-Cutting Speed-Feed- depth of cut- machining time calculation - machining time for Face milling and Peripheral milling. Indexing- Types of indexing head- direct indexing heads, principles of direct indexing, direct indexing mechanisms-simple indexing head, plain or simple indexing-Angular indexing. Broaching-The process of broaching: Different types of broaching machines and its working principle. Different types of broaching tools: Elements of broaching tool.

05Hrs

Module 2

Grinding: Taper grinding - gear tooth grinding - wet and dry grinding.Grinding wheel: Specification of grinding wheels - abrasives - bond grain - grade - structure – different types of grinding wheels according to shape-standard marking system of grinding wheels.Dressing of wheel. Machining time calculation: In surface grinding – face grinding - circumferential grinding - cylindrical grinding. Tool and cutter grinder.Calculation for regrinding of single point tools, milling cutters, reamer, drills, broaches.

05Hrs

Module 3

Jig boring and Jig Grinding-Jig boring: Different types of machines - parts of machine - function - different tools for jig boring Jig grinding: Different types of jig grinding machines - types of operations on jig grinding machine. Super finishing process - Honing: The purpose – process of honing – the honing machine – advantage and dis-advantage of honing. Lapping: The process - purpose - machine - lapping tool and medium - advantages and dis-advantages of lapping. Electric discharge machining: Principle of operation process of sparking – sparking machine – main parts of the machine – thread cutting on sparking machine. Electrode: The material for electrode -type of electrodes - roughing and finishing – allowances provided while designing.

08Hrs

Module 4

Manufacturing processes-Casting: Process of casting - Advantages and disadvantages of casting- Explain types: Sand casting - Investment casting - Centrifugal casting - Die casting. Mechanical working of metals: Hot working - cold working - merits and demerits-Types of hot working: Rolling - Forging - Piercing-Drawing- Spinning- Extrusion- Types of cold work: Cold rolling - Cold drawing - Bending - Squeezing - Peening - Spinning. Powder metallurgy: Process - Manufacturing of powder: Character of powder - Safety in handling - Size of powder - Blending of powder - Compacting – Pre-sintering- sintering - secondary operation. Product produced- advantages - disadvantages – limitations.

08Hrs

Module 5

Processing of ceramics and glass-production of metal powders: Compaction – Sintering and Finishing – Design, Considerations for powder metallurgy and Process capability – Shaping of ceramics –Forming and shaping of glass – Design considerations for ceramics and glass.

04Hrs

Text Books:

1. Sudarshan T S, Surface modification technologies - An Engineers Guide, Marcel Dekker, Newyork, 1989
2. Varghese C.D, Electroplating and other Surface Treatments - A Practical Guide“, TMH, 1993.
3. Workshop Technology – Chapman

Reference Books:

1. Modern W/s Technology - Wright Baker
2. All about machine tools - H.Gerling
3. Machine Technology- P.M Johnston

Course code: 17VT302 Total Hours: 30 hours	MATERIAL TECHNOLOGY & HEAT TREATMENT	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to enable students : 1. Highlight the atomic bonds, in the structure of metal 2. Awareness of the crystalline structure, solid solutions, solid phase and phase diagram. 3. General awareness of solidification of metals 4. Awareness of general HT terms, process and charts, Heat Treatment Equipment, microscopic testing of material.				
Course outcomes	Students after the completion of this course will be able to : 1. Understand the Structure and Properties of various Materials and their importance in Modern Technology. 2. Identify the structure of materials - Unit cell, space lattice, BCC, FCC, & HCP structure, Atomic Packing factor. 3. Understand the various process of Heat Treatment 4. Know the Need and uses of non-ferrous metals and alloys in engineering application.				

Module 1

Atomic bonds -Explain the atomic bond, Classification of atomic bond: primary bond - secondary bond Primary Bond: Ionic bond – covalent bond - metallic bond, compare the different types of bond: Ionic and metallic - covalent and metallic. Crystalline structure - Introduction - Types of solids: crystalline solid – non crystalline solid -explanation of crystal and crystal structure, Space lattice - Explain unit cell and space lattice -Classify the space lattice: body centered cubic lattice - face centered cubic lattice-closed packed hexagonal lattice, Crystal imperfection-Explain crystal imperfection effect of crystal imperfection on the mechanical properties of metals- how defects happen- explain 4 types of point defects (Vacancies, interstitial , Frenkle , Substitution) , explain line defects , explain surface defects (grain and twin boundary)

06 Hrs

Module 2

Solid solutions - Solid solutions - classify – explain, Solid phases and its types – Explanation on what is solid solution, types of solid solution (interstitial solid solution and substitution solid solution), Explanation on Basic phase diagram, explain alloy. Solidification of metals - Explain the solidification process -explain the structural changes in steel - Explain iron carbon diagram (more specific up to 2 % carbon&1200 degree centigrade). Metallurgical microscope - Metallurgical microscope – working principle, uses. Parts and function. Care to be taken while in use. Procedure of preparing the specimen for microscopic testing. **05Hrs**

Module 3

Heat Treatment - Definition, scope and safety, Principle of Heat Treatment, interpretation of iron carbon diagram, TTT diagram, Microscopic Structure and Structural Transformation, Process and process variables – sequence of operation-heating, soaking and cooling, heating and cooling rate, Heat Treatment temperature and holding time, Types of Heat Treatment – stress relieving, annealing, normalizing Hardening and Tempering, Case hardening and surface hardening and special Heat Treatment process, Carburising – Pack carburising, vacuum carburising, nitriding, gas nitriding and plasma nitriding, Localised case hardening-induction hardening and flame hardening, Special Heat Treatment –Martempering and Austempering, Sub-zero treatment. Heat Treating Equipment - Heating media – Furnace – Fuel fired furnace, electrically heated furnace, bath furnace and vacuum furnace, Fuel used in furnace heating –Solid, liquid and gaseous fuel, Advantages and disadvantages of bath furnace and hearth furnace, Quenching media – water, oil, gas, aqueous solution and salt bath, Tempering measurement and control – thermometer, pyrometer, thermocouple, &segar cone.

07Hrs

Module 4

Post Heat Treatment - Remove of scale – acid pickling and grit blasting – alkaline detergent cleaning and degreasing – straightening, Hydrogen de-embrittlement treatment. Heat Treatment of different materials - Heat Treatment of tools steels – Hot worked tool steel & cold worked tool steels, high speed steel, stainless steels and spring steels, Heat Treatment of non-ferrous material – aluminium and its alloys and copper and its alloys. Possible defects and remedies in Heat Treatment - Low hardness and strength after hardening, soft spots, oxidation and carburisation, overheating and burning, formation of cracks, - development of cracks- distortion and warping, Discuss causes and remedies. **04Hrs**

Module 5

Surface Treatment - Mechanical cleaning and finishing – vibratory finishing, belt standing, wire brushing, buffing and electro polishing, Chemical cleaning – vapor degreasing, solvent cleaning, alkaline cleaning. Ultrasonic cleaning and acid pickling, Burr removal – design to facilitate or eliminate burr removal, Coatings – painting, dipping spraying, powder coating – blackening – electroplating, Vaporised metal coating – vacuum metalizing, (sputtering) physical and chemical vapor deposition. Planning for Heat Treatment and case study - Preparation of the work piece – setting of furnace Case study and revision. **04Hrs**

Module 6

Modern Metallic materials: Dual phase steels, Micro alloyed, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) steel, Maraging steel - Intermetallic, Ni and Ti aluminides - Smart materials, shape memory alloys - Metallic glass - Quasi crystal and nano crystalline materials, bio materials. **04 Hrs**

Text Books

1. Thomas H. Courtney, Mechanical Behavior of Materials, McGraw-Hill, 2000.
2. Flinn, R.A. and Trojan, P.K., Engineering Materials and their Applications, (4th Edition), Jaico Publishing, 1999.
3. Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta and John J. Moore, Introduction to Nano Science and Nanotechnology, CRC Press, Boca Raton, 2009.

Reference Books:

1. Material Science & Process - HajaraChoudhari
2. Material and Metallurgy - V.K Manchanda
3. Material Science - R.S Khurmi
4. Material Science - O P Khanna
5. Materials for Engineering (Part 1&2) - P. S Houghton
6. Materials for Engineering (Vol 1&2) - P. S Houghton
7. Materials and processing in manufacturing – E. Paul DeGarmo, J.T. Black and Ronald A. Kohser
8. Heat Treatment Principle and techniques - T.V. Rajan, C.P. Sharma
9. Material Science and Process - G.B.S. Narang
10. Heat Treatment Handbook - Prabhu Dev

Course code : 17VT303 Total Hours: 30 hours	STRENGTH OF MATERIALS-I	L	T	P	C
		02	-	-	02
Course objectives	The objective of this course is to enable students : 1. To understand the basic concepts and terms on materials. 2. To understand the stresses developed in bars, compounds bars, shafts, cylinders and spheres. 3. Understand the relationship of direct stresses 4. Understand the effect of direct shear stresses 5. Highlight the importance of thermal effect 6. Know the effect of load on struts and columns				
Course outcomes	Students after the completion of this course will be able to : 1. Apply concepts of strength of materials to obtain solutions to real time Engineering problems. 2. Students will analyze the terms involved and apply knowledge for deformation. 3. Understanding the mechanical terms and deformation behavior for different loads				

Module 1

Simple stresses and strain - Introduction - importance of studying strength of material in Tool making, Load - definition and explanation about tensile load and compressive load - effect of load in elastic material, Stress and strain, tensile stress, compressive stress and strain- plain rod in a state of compression – elasticity elastic limit and permanent set, Hooke's Law : Modules of elasticity – problems, Stress and strain produced in a bar by its own weight – problems, Elongation of bar of varying cross section - stresses in composite bars - problems, Elastic constants-Effect of axial load on lateral dimensions lateral strain-linear strain - Poisson's Ratio problems, Bulk modulus-Relation between Bulk modulus and Youngs' modulus, problems, Tensile test: - tensile test for mild steel - stress - strain curve for M.S. - stress strain curve for different materials, Compression test.

07 Hrs

Module 2

Direct, shear stress - Shear force - shear stress - comparison of shear and normal stresses - deformation due to shear stress - shear strain - modules of rigidity - modules of rigidity of different materials - workshop related problems.

05Hrs

Module 3

Thermal effect on stress and strain - Nature of stress developed by preventing expansion due to heat in machine members - equation for the stress due to change of temperature when the

expansion is completely prevented - equation for the stress due to change of temperature when the expansion is partially prevented - practical examples of thermal stresses in Tool Engineering.

06 Hrs

Module 4

Struts and Columns - Definition: Strut – Column, Effect of axial load on column-failure of a column or strut formula related with the compressive load - buckling load, Euler's Column theorem: Expression for buckling load assumption in Euler's column theory, Types of end conditions of columns - both the ends hinged -both ends fixed - one end fixed and other end hinged - one fixed and other end free – problems related with the end conditions - finding punch length in press tools.

06Hrs

Module 5

Thin Cylinders, Spheres and Thick Cylinders - Stresses in thin cylindrical shell due to internal pressure circumferential and longitudinal stresses and deformation in thin and thick cylinders, spherical shells subjected to internal pressure, Deformation in spherical shells, Lamé's theorem.

06Hrs

Text books

1. S. S. Bhavikatti, "Strength of Materials", Vikas publications House-Pvt. Ltd., 2nd Edition, 2006
2. Hibbeler, R.C., "Mechanics of Materials", Pearson Education, 2007.

Reference books:

1. Strength of Material-Vol.I - Timoshenko
2. Strength of Material-Vol.II - Timoshenko
3. Strength of Material - RS Khurmi
4. Strength of Material - Ramamrutham
5. Strength of Material - Surendra Singh
6. Strength of Material - William A Nash
7. Strength of Material - L.B.Prasad
8. Machine Design -Pandya & Shah

Course code: 17VT304 Total Hours : 30 hrs	PRESS TOOL TECHNOLOGY-I	L 02	T -	P -	C 02
Course Objectives	The objective of this course is to make the students : 1. Awareness of different types of sheet metal processing using press tools 2. Ability to determine cutting force & cutting clearance. 3. Awareness of basic design of press tools. 4. Ability to design a strip lay out. 5. Familiarization of different types of punches & Die blocks. 6. Recognition of the function and design of strippers and stoppers. 7. Familiarization with the function and design of the pilots. 8. Recognition of the use of ejectors, shedders, fasteners and dowel in a press tool.				
Course outcomes	Upon successful completion of this course, the trainee will be able to: 1. Explain the necessity of press tool for Manufacturing of Stage, Progressive, Bending and Compound tools. 2. Analyze the design constraints in the given problem. 3. Apply the design rule for designing and manufacturing of press tools. 4. Design and Drafting of press tools for considering real time issues of Manufacturing, Testing and Assembly.				

Module 1

Introduction to press tools- Different Press Tool operations, Awareness on different types of press tools. Stock material- Relationship of piece part and stock strip, Material- Stock materials used in press work -mechanical properties of different stock material -choosing material for the required press operation -preparation of stock material-Standards – types behaviour, Differentiate stock strip and unit stock. Theory of Shearing- Shearing theory description in press tool, Critical stage of shearing.**04 Hrs**

Module 2

Cutting Force & Cutting clearance- Calculation of cutting force for press tool operation, Selection of suitable press, Methods for reducing cutting force, cutting clearance: Explanation - Importance of cutting clearance, Typical appearance characteristics: Identify less or more clearance by visual inspection of the component, Relationship between piece part size to punch and die size, determine punch and die dimension. Basic design of Guide Plate tool- Working principle of guide plate tool - when to adopt guide plate tool - Importance of each part of the tool -design of guide plate tool -Selecting Material-Planning production.**05 Hrs**

Module 3

Elements of guide plate tool- Punch – dies – Punch – Base plate – Guide block –Dowels – Fasteners – Clearance – Angular Clearance– Shank, Land and Angular clearance- Importance of angular clearance - methods used in providing angular clearance to be provided depending on stock material. Basic design of Progressive tool- Working principle of progressive action – Progressive Guide Plate tool, Compare between single station Guide plate tool and Progressive Guide Plate tool. Strip lay out- Importance of strip lay out, Different types of strip lay out: - narrow run - wide run- single row - two pass - double row lay out – gang dies - angular lay out - shape of the blank -production requirement grain direction - burr side -stock material, Strip lay out for blanking tool- Cut off-parting –notching - trimming-progressive tools, Strip lay out for blanking tool- Cut off-parting –notching - trimming-progressive tools. **05 Hrs**

Module 4

Die blocks & Punches- Die blocks, Types of dies – Solid dies – Split dies or sectional die block, Requirement of die blocks-different methods of construction of die blocks-selection of die blocks, Selection- Material for die blocks- Heat treatment, Punches, cutting punches- non cutting punches – hybrid punches, Types of punches, Selection of punches depending on the work- material of punch. Strippers- Function of a stripper, Types of stripper, Constructional details of stripper - Spring strippers -Clamping spring stripper - Non clamping spring stripper - Piloting through spring stripper -Compensating washer - Spring around stripper bolts-Stripper bolt suspension, Stripping force- Stripping force for blanking and piercing. Stoppers- Basic stop principles - Stop position - Stop categories -Primary - secondary – final, Construction of different types of stoppers- plain pin stop - headed pin stop - disappearing pin stop – finger stop - operation - pusher stop - trigger stop. **08 Hrs**

Module 5

Pilots- Purpose of pilotsDifferentiating between indirect piloting and direct piloting -Pilot size - Pilot length -Pilot opening in die - Pilot opening in die shoe, Types of pilots - Function of different types of pilots -retractable pilots - removable type pilots - pilot in. Side cutters-Function of side cutters, Advantages of side cutter. Ejectors and shedders- Ejector – Function of ejector, Shedder - Function of shedder - Types of shedders – Positive shedder -Compression shedder- Shedding pins, knock outs- Function-Distinguishing between direct knockout and indirect knock out. Fasteners and dowels- Dowels: Function-Types of Dowels used in tooling - precaution while dowelling, Fasteners: Screws - Function - Types of screws like – socket head

screws - counter sunk screw head screw - cheese head screw -set screw- Non threaded. Fasteners-Rivets-cotter pins. Shank- Different types of shanks employed in a press tool, Location of shank –Importance for locating shank in correct position – Shank point location (Arithmetical method)-Shank point location (graphical method). **08 Hrs**

Text Books

1. Tool Design – Donaldson
2. Die Design Fundamentals - Paquin

Reference Books

1. Basic Die Making - Ostergarrd
2. American Society of Metals - Hand Book 8th edition.Volume 4 forming.
3. Advanced Die Making - Ostergarrd
4. Fine blanking Seminar Notes - N T T F
5. Fundamentals of Tool Design - A.S.T.M.E
6. Tool Engineers hand book
7. Die Design Hand book
8. PSG Hand book
9. CMTI Hand book

Course code: 17VT305 Total Hours: 30 hrs	JIGS & FIXTURES	L	T	P	C
		2	-	-	2
Course Objectives	The objective of this course is to make the students understand : 1. Awareness of the difference between jig and fixture. 2. Highlight the types of jig and fixture. 3. General awareness of mounting jig and fixture on a machine tool. 4. Awareness of elements of jig and fixture. 5. Awareness of design of jigs, fixture. 6. General awareness of cutting forces acting on jig and fixture 7. Highlight the common failures and heat treatment of jig and fixture.				
Course Outcomes	After successful completion of the course, the students should be able to : 1. Categorize and justify the requirements of Jigs and Fixtures for Manufacturing, Testing and Assembly 2. Describe and implement various indexing mechanics in manufacturing. 3. Analyze problems related to Jigs and fixtures in Manufacturing, Testing and Assembly.				

Module 1

Introduction to Jigs and fixture-Introduction – jig, fixture, Function of jig, fixture, Difference between jig and fixture, Economic use of jig and fixture. Planes of movement- Principle of location, Freedom of movement of an object.

06 Hrs

Module 2

Possible movements of work piece- Arresting the freedom of movement, Clamps, stoppers, in a jig fixture. Location of work piece- Purpose of location, Fool proofing of work, Body, feet of jig, fixture, chip control.

06 Hrs

Module 3

Different types of jigs- Template jig, Table jig, Plate jig, Angle plate jig, Modified angle plate jig, Sandwich jig, Box jig, Channel jig, Leaf jig, Indexing jig.

05Hrs

Module 4

Different types of fixture-Plate fixture, Angle plate fixture, and Modified angle plate fixture, vice jaw fixture, Fixture and machine relation, Jig and machine relation. **05Hrs**

Module 5

Elements of jig and fixture- Clamps, Stoppers, Supports, Plugs, Types of drill bushes. Jig, fixture and cutting tool relation- Types of tools, Cutting tool setting, Chip direction, Chip removal. Design steps to be followed for Jigs and Fixtures- Design principles - care – procedure. Failure of jig and fixture- Failure of elements, failure of clamping-Discuss the above with case study. Effect of heat treatment on jig, fixture elements- Cutter setting block, body, feet, Drill bushes. **08Hrs**

Text Books:

1. Jigs and Fixtures - Hiran E Grant
2. Jigs and Fixtures Design - Franklin D Jones

Reference Books:

1. Jigs and Fixtures - Joshi
2. Jigs and Fixtures - Hiramegrant
3. Die Design Fundamentals - ASTME
4. P S G Hand

Course Code : 17VT306	QUALITY MANAGEMENT-III	L	T	P	C
Total Hours: 30 hours		02	-		02
Course Objectives	The objective of this course is to enable students : 1. To understand the basic concepts on measurements and their terms. 2. To provide knowledge on various measurement equipment sand components. 3. To learn the procedure adopted to measure the dimension of the components				
Course outcomes	Students after the completion of this course will be able to : 1. Students will have thorough knowledge on different measurement components. 2. Understanding the terms and knowing the various parameters in measurements				

Module 1

Hardness checking - Hardness – property, checking methods - Brinell - indenter used - load – method, Rockwell principle - RA, RB and RC- indenter used lead for different scales, Vickers’s hardness - indenter used – load, Shore scleroscope hardness test. **06 Hrs**

Module 2

Interferometry - Principles of Optical Interference Wave Length wave in phase – wave out of phase – formation of interference bands, Interferometry Applied to Flatness Testing – optical flat – material size – method of checking, Fringe Pattern Obtained On: flat surface – convex surface – concave surface – surface with high points – surface with low edges, Measurement of Slip Gauge Size – use of interferometer. **06 Hrs**

Module 3

Form and position features -Straightness – definition, Measurement of straightness, Flatness - definition - testing - surface plate – straight edge method -auto collimator method - use of optical flats, Parallelism - dial indicator - use - types - plunger type working - working principle - precautions -universal dial indicator-working working principle – precautions, Parallelism of 2 axes- parallelism of 2 planes parallelism of axis to a plane, Squareness - try square - indicator method –auto collimator method, Measurement of circularity - ovality - lobbing- use of dial indicator and V block – Talyrond, Concentricity - checking using dial indicator, Run out – checking. **06 Hrs**

Module 4

Miscellaneous measurement -Checking the angle of a piece tapered at one end, to check the angle of a tapered hole, Gear Tooth Vernier – tooth thickness measurement – gear tooth caliper, plug method for checking Pitch Diameter and Tooth test.

06 Hrs

Module 5

Surface texture measurement -Meaning of surface texture - difference between length measurement and surface texture measurement, Effective profile, Method of Measuring – inspection by comparisons - direct instrument measurement, Stylus probe instruments – essential parts, Profilometer, Tomlinson’s surface meter, The Taylor Hobson Talysurf , The Sigma Micotest, The Ruler ‘Mercin’ Roughness Instrument, Talysurf (electronic surface indicator), Analysis of surface traces – Peak to valley height – Root Mean Square (RMS) Value – Centre line average method.

06 Hrs

Text Books

1. Beckwith Marangoni and Lienhard, “Mechanical Measurements”, Pearson Education, 6th Edition, 2006.
2. A. K Sawhney, “A course in Mechanical Measurements and Instrumentation”, DhanpatRai Publications.
3. Alan S. Morris, “The Essence of Measurement”, Prentice Hall of India, 1997

Reference books:

1. Engineering Metrology - R.K Jain
2. Mechanical and Industrial measurements - R.K Jain
3. Dimensional Metrology - M.K Khare
4. Engineering Metrology - K.J Hume

Course code: 17VT308	TOOL DESIGN DRAWING-I FUSION 360	L	T	P	C
Total Hours: 90hrs		--	-	06	06
Course Objectives	1. The objective of this course is to enable students : 2. Understanding the basic principles and designing various types of fixtures. 3. Understanding the basic principles and designing various types of jigs. 4. Training in the ability to design different types of Guide Plate Tool. 5. Training in the ability to design different types of Blanking Tool with Die sets. 6. Training in the ability to design different types of Progressive tool.				
Course outcomes	Students after the completion of this course will be able to: 1. Design and drafting various Jigs and Fixtures using appropriate software package. 2. Design the Progressive tool and blanking tool.				

LIST OF EXPERIMENTS

1. **Design of Fixtures-** Design of Turning Fixture, Design of Milling Fixture and Design of Grinding Fixture. **-30 Hrs.**
2. **Design of Jigs-** Design of Plate Jig, Design of Box Jig, Design of Leaf jig and Design of Indexing Jig. **– 30Hrs.**
3. **Design of Guide plate tool-** Design a single stage guide plate tool and design of three stage guide plate tool.**15 Hrs**
4. **Blanking Tool with die set – 15 Hrs.**
5. **Design of Progressive Tool-** Design of Progressive tool incorporating travelling stripper and Design of Progressive tool incorporating one or more of the following features like traveling Stripper with split dies, Cut –off punches with side cutter.

30 Hrs

Course code:17VT309 Total Hours: 60- hours	MATERIALS LABORATORY	L	T	P	C
Course Objectives		-	-	4	4
Course outcomes	The objective of this course is to enable students : 1. Introduction to basic characterization techniques for materials, such as Hardness testing, Tensile testing, Shear testing, Compression, Bending, Fracture testing, Fatigue testing & Impact testing. 2. To study the different methods to enhance the properties of materials from few mechanical & metallurgical processes like heat treatment. Students after the completion of this course will be able to : 1. Students will be able to demonstrate the knowledge, skills to conduct & analyzing the results with different mechanical testing. 2. Identification of Metals & Microstructure examination.				

LIST OF EXPERIMENTS

1. **Tension Test**- To determine mechanical properties such as ultimate tensile strength, elastic modulus, proportionality limit, yield point, fracture stress, percentage elongation & reduction in area of metals & alloys and also study the behavior of material & characterize types of fracture under tensile load.
2. **Compression Test** -To conduct compression test on the given material and to determine properties such as compressive strength, modulus of elasticity, percentage constriction & percentage increase in area.
3. **Shear Test** - To determine ultimate shear stress of the given specimens in single and double shear.
4. **Bending Test** -To study the characteristics of materials under the gradually increasing flexural loading and to determine Modulus of rupture, Modulus of elasticity, Maximum shear stress.

5. **Impact Test** - (Charpy and Izod) - To find out the impact strength of the given notched specimens.
6. **Brinell hardness Test** -To determine the Brinell Hardness Number (BHN) of the given specimens.
7. **Vicker's Hardness Test** - To determine Vickers Hardness Number for a given specimen.
8. **Wear Test** - To determine the wear rate of different materials by using pin and disc apparatus.
9. **Torsion Test** - To determine the torsional shear stress

Course code: 17VT311 Total Hours: 01	CONSTITUTION AND ETHICS	L	T	P	C
		01	-	-	-
Course Objectives	The objective of this course is to enable students : 1. To provide basic information about Indian constitution. 2. To identify individual role and ethical responsibility towards society. 3. To understand human rights and its implications				
Course Outcomes	Students after the completion of this course will be able to : 1. Have general knowledge and legal literacy and thereby to take up competitive Examinations 2. Understand state and central policies, fundamental duties 3. Understand Electoral Process, special provisions 4. Understand powers and functions of Municipalities, Panchayats and Co-operative Societies. 5. Understand Engineering ethics and responsibilities of Engineers. 6. Have awareness about basic human rights in India				

Module-1

Introduction to the Constitution of India, The Making of the Constitution and Silent features of the Constitution, Preamble to the Indian Constitution Fundamental Rights & its limitations.

3 hrs

Module-2

Directive Principles of State Policy & Relevance of Directive Principles State Policy Fundamental Duties, Union Executives – President, Prime Minister Parliament Supreme Court of India.

3 hrs

Module-3

State Executives – Governor Chief Minister, State Legislature High Court of State, Electoral Process in India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th & 91st Amendments.

Module-4

Special Provision for SC & ST Special Provision for Women, Children & Backward Classes
Emergency Provisions, Human Rights –Meaning and Definitions, Legislation Specific Themes
in Human Rights- Working of National Human Rights Commission in India, Powers and
functions of Municipalities, Panchyats and Co - Operative Societies. **3 hrs**

Module-5

Scope & Aims of Engineering Ethics, Responsibility of Engineers Impediments to
Responsibility,Risks, Safety and liability of Engineers, Honesty, Integrity & Reliability in
Engineering. **3 hrs**

Text Book

1. Durga Das Basu ‘Introduction to the Constitution of India’ (Students Edn.) Prentice Hall
EEE – 2001

2. ‘Engineering Ethics’ by Charles E Haries, Michael. S Pritchard and Michael J Robins
Thompson Asia, 2003

3. Constitution of India & Professional Ethics by Raman &Yaji

Reference Books

1. ‘An Introduction to the Constitution of India’ by M V Pylee, Vikas Publishing. 2002

2. Engineering Ethics _ by M Govindarajan, S Natarajan, V S Senthail Kumar, Prentice Hall of
IndiaPvt Ltd. New Delhi, 2004

3. Brij Kishore Sharma,“Introduction to the Constitution of India”, PHI Learning Pvt.
Ltd., New Delhi, 2011.

4. Latest Publications of Indian Institute of Human Rights, New Delhi.

Course code: 17VT312 Total Hours: 120hrs	WORKSHOP-III	L	T	P	C
		-	-	08	08
Course Objectives	The objective of this course is to enable students : 1. Understanding the concepts of different operations such as Bench work, milling and Turning. 2. Understanding the concepts of different operations such as surface grinding and cylindrical grinding.				
Course outcomes	Students after the completion of this course will be able to: 1. Work independently on different operations such as Bench work, milling, Turning, surface grinding and cylindrical grinding.				

LIST OF EXPERIMENTS

1. **Manufacturing of elements of Progressive Tool**-Top Plate, Bush, Punch holder, Stripper plate, Die plate.
2. **Manufacturing of elements of Progressive Tool** -Bottom plate, Spacer, Extension table, Finger stopper.
3. **Manufacturing of elements of Progressive Tool** -Shank, Blanking punch, Piercing punch, Pilot, Thrust Plate.
4. **Types of fits on Progressive Tool**- Offset Fit, Universal Fit.

B.VOC FOURTH SEMESTER SYLLABUS

Course code: 17VT401 Total Hours: 30 hrs	MOULD TECHNOLOGY	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to enable students : 1. Familiarization in the use of plastics in molding industry. 2. Familiarization of the working of injection moulding machine 3. Awareness of basic terminology of injection moulds and 4. Familiarization with mould material and their specification 5. Ability to determine the number of cavities and parting surface of an injection mold. 6. Highlight the importance of elements of feed system and ejection system in an injection mould.				
Course Outcomes	Students after the completion of this course will be able to : 1. Explain the importance of elements of feed system and ejection system in an injection mold. 2. Explain the working of injection moulding machine. 3. Describe the design of the moulds with split cavities, side cores and side cavities.				

Module 1

Plastic in Moulding Industry- Introduction to polymerization, Thermoplastics and Thermoset plastics: Types -Property – Application, Fillers and Additives: Varieties - effect - Reinforcement of plastics, Identification of plastics: simple tests, Plastics for commercial products. Injection Moulding Machine- Different types of injection moulding machine - Plunger injection cylinders - Pre-plasticizer, two stage, plunger injection cylinder, two stage screw injection cylinder - Reciprocating screw injection cylinder - Purging - Injection moulding machine basic arrangement - The screw - The nozzle, Machine specifications -Injection capacity or short capacity - Plasticizing capacity-Injection rate or injection velocity - Injection pressure - Clamping force - Maximum Daylight.**05Hrs**

Module 2

Basic Terminology- Elements of mould - Function - Fixed half - moving half - Impression - cavity - core - sprue bush - register ring - runner - gate - guide pillars and bushes - heel blocks - rest button - sprue breaker - ejector - ejector retainer - push back pins, Moulds and moulding methods, Mould material specification – selection based on type of material being molded – effect of wear occurring during moulding. Number of cavities calculation-Shot weight calculation - Plasticizing capacity calculation -Cycle time calculation - Clamping force calculation - Determination of number of cavities - Determination by shot capacity - by plasticizing capacity- by clamping capacity. Parting surface- choosing parting surface for different components – relief of parting – reason for relief for parting surface, Venting: Functions of air vents – Position of air vents for different components. **06Hrs**

Module 3

Feed system- Parts of feed system: Runner- Function-runner cross section shape - runner size - Gates - Function of gates - position of gates - balanced gates - types of gates - advantages of different types of gates - disadvantages of different types of gates, Runner diameter calculation – Gate calculation. Ejection system-Ejector grid: Types of ejector grid - Ejector plate assembly - Functioning -Ejector plate - retaining plate - guiding and supporting ejector plate assembly - ejector rod and ejector bush - Ejector plate assembly return system. Push back pin return system - spring return system - stop pins, Ejection methods - Pin ejection - D shaped ejector pins - sleeve ejection - blade ejection - valve ejection - air ejection - stripper bar ejection - stripper plate ejection - stripper ring ejection - Ejection from fixed half - Sprue pullers- Function and design of sprue puller. Plastic Shrinkage- Shrinkage - Explain shrinkage - Effect - Factors governing shrinkage - Values of shrinkage, Determine the core and cavity dimensions.

07 Hrs

Module 4

Temperature controlling for moulds- Need of temperature controlling for moulds – methods, Cooling method -Cooling integer type mould plates - Cooling insert bolster assembly -Cooling bolster - cooling cavity inserts - cooling core inserts - Water connections Adapters - position of water connection – plugs, Mould cooling calculation - Typical temperature - amount of water to be circulated per hour -solidifying time - length of cooling channel .examples - Estimation of cooling period. Mould cycle- Elements of mould cycle – Importance of mould cycle, Mould cycle diagram – Procedure – Preparation of mould cycle diagram during mold tryout.

05 Hrs

Module 5

Cavities- Selection of splits- Design of moulds with splits- External undercut components - Position of joint line, Splits - sliding splits - guiding and retention of splits - mould plate designs - split designs, Operation of Splits-Finger cam actuation -Dog leg actuation - Cam track actuation - Spring actuation -Hydraulic actuation, Split locking method - Open channel type - Closed channel type, Split safety arrangement - Spring detente method - spring loaded method. **Side core and side cavity-** Selection of side core and side cavity design for the required components - Integral side core or side cavity, Assembly details - Construction - guiding arrangement, Method of actuation - Methods used in actuating the side core and side cavity. **07Hrs**

Text Books:

1. Introduction of injection mould design - Pye

Reference Books:

1. All about Plastics-NI George
2. Die Moulds and Jigs - V.Vladimir
3. Plastic material & Process - Schwartz

Course code: 17VT402 Total Hours: 30 hrs	PRODUCTION TECHNOLOGY - IV	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to enable students to have: 1. Knowledge in health, safety and security at the workplace. 2. Knowledge in Non-conventional machining. 3. Awareness about basic practices that improve effectiveness of working with others in an organizational set-up. 4. Awareness about the importance and levels of maintenance of Machine tool. 5. Awareness about the additive machining.				
Course Outcomes	Students after the completion of this course will be able to: 1. Take the basic precautions and simple control measures that can be implemented to reduce the risk of fire in workplace. 2. Proper use of safety devices, practice of rescue and first aid procedures. 3. Proper maintenance of machine tools to prevent break down.				

Module 1

Health and safety – Protective clothing/Equipment, Hazards, Safe working practices, Methods of accident prevention, Good housekeeping practices at various areas. Fire safety - Types of fires, Rescue techniques applied during fire hazard, proper housekeeping in order to prevent fire hazards, correct use of a fire extinguisher. Emergencies, rescue and first-aid procedures - Appropriate first aid to victims were required e.g., in case of bleeding, burns, choking, electric shock, poisoning etc., organize loss minimization or rescue activity during an accident in real or simulated environments, Emergency procedures: raising alarm, safe/efficient, evacuation, correct means of escape, correct assembly point, roll call and correct return to work, Accident/incident report. (Incident Report includes details of: name, date/time of incident, date/time of report, location, environment conditions, persons involved, sequence of events, injuries sustained, damage sustained, actions taken, witnesses, supervisor/manager notified), Correct method to move injured people and others during an emergency.

07 Hrs

Module 2

Non-conventional machining - Chemical machining: principle of operation-chemical milling - chemical blanking - chemical engraving, Ultrasonic machining: Working principle of the machine tool material and tool size - application of ultrasonic machining, Water jet Machining, Abrasive jet machining: Principle of operation - element and the influence of the process - application of the process, Laser beam machining: Principle of these machining –machining process – applications, Electron beam machining: Working principle of the EBM - process of the machining - application of the process, Plasma arc machining: Principle of plasma arc machining – different parts of the machine – application of the process, Ion Beam machining: Principle of the machining - different parts of the machine – applications. **06 Hrs**

Module 3

Working effectively with others at work - Accurately receive information and pass on information to authorized persons who require it and within agreed timescale and confirm its receipt, display appropriate communication etiquette while working (Communication etiquette: do not use abusive language; use appropriate titles and terms of respect; do not eat or chew while talking (vice versa) etc., Demonstrate responsible and disciplined behaviors at the workplace. (Disciplined behaviors: e.g. punctuality; completing tasks as per given time and standards; not gossiping and idling time; eliminating waste, honesty, etc.), Escalate grievances and problems to appropriate authority as per procedure to resolve them and avoid conflict.

07 Hrs

Module 4

Machine tool Maintenance - Importance of maintenance of machine tools, Types of maintenance - Preventive - Break down. Additive manufacturing - Introduction to additive manufacturing, Benefits of additive manufacturing, Functional principle of AM.

05 Hrs

Module 5

Micro and Nano Manufacturing - Introduction to Micro and Nano manufacturing technology, advantages and applications of nanotechnology, Overview of Nano Fabrication Methods: Top-down and bottom-up approaches, lithography, deposition, Chemical Vapor Deposition, Physical Vapor Deposition, etching, and material modification methods, processes and equipment.

05 Hrs

Text Books:

1. Kalpak Jain, Manufacturing Engineering & Technology, Addison Wesley, 1997

2. Poul De Garmo, J.T.Black, R.A.Kosher, Materials and Processes in Manufacturing, Prentice Hall of India, 1997.
3. Gibson, I., Rosen, D.W. and Stucker, B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.

Reference books:

1. Modern W/s Technology - Wright Baker
2. All about machine tools - H. Gerling
3. Workshop Technology (Part I - Part III) - Chapman
4. Machine Technology Vol.1 – Vol.4 - P.M Johnston
5. Production Technology - Jain, Agarwal

Course code: 17VT403 Total Hours: 30 hrs	STRENGTH OF MATERIALS-II	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to enable students : 1. To provide knowledge on bending stress and torsion on materials 2. To understand the stresses developed in bars, compounds bars, beams, shafts. 3. To analyze the stress and strain on mechanical components. 4. To identify and quantify failure modes for mechanical parts.				
Course Outcomes	Students after the completion of this course will be able to : 1. Apply concepts of strength of materials to obtain solutions to real time Engineering problems 2. Ability to understand different kinds of loading in mechanical engineering components. 3. Ability to apply the fundamentals of mechanics of solids, stress analysis, theories of failure and material science in the design of machine components.				

Module 1

Bending stress - Introduction: importance in tool engineering, Revision on Equilibrium of forces and moment of a force, Moment of inertia, Centre of gravity and centroid. Introduction to Beams, Types of beams and Loads acting on beams, Problems on cantilever and simply supported beams - theory of simple bending - bending stress - position of neutral axis - section modules - $M/I = F/Y = E/R$ – Problems using bending equation. **06 Hrs**

Module 2

Torsion of shaft - Shafts - function of shaft – Introduction to rigidity modulus, effect of torque on a shaft - twisting movement - Torsional stress, Torsional rigidity, strength of a shaft - polar moment of inertia - power transmitted by a shaft - angle of twist – Torsional equation, Problems using torsional and power transmitted by shaft. **06 Hrs**

Module 3

Torsion of Springs - Types of springs - bending spring - torsion spring, Forms of springs - leaf spring - helical springs - closely coiled helical spring- open coiled helical spring- compound spring - springs in series - springs in parallel, Closely coiled helical spring subjected on axial

load - closely coiled helical spring subjected on axial twist - calculation of number of turns - open coiled helical, Spring subjected in axial load-open coiled helical spring subjected to axial twist - bending stress - deflection of spring Problems on helical springs.

06 Hrs

Module 4

Static Strength - Static loads and factor of safety. Theories of failure- maximum normal stress theory, maximum shear stress theory, maximum strain theory, strain energy theory, distortion energy theory. Failure of brittle and ductile materials, stress concentration, determination of stress concentration factor.

06 Hrs

Module 5

Fatigue Strength - Introduction, S-N Diagram, low cycle fatigue, high cycle fatigue, endurance limit, modifying factors: size effect, surface effect, stress concentration effects, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.

06Hrs

Text Books:

1. Hibbeler, R.C., "Mechanics of Materials", Pearson Education, 2007.
2. Joseph E Shigley and Charles R. Mischke, Mechanical Engineering Design, McGraw Hill International edition, 6th Edition 2009.
3. V.B. Bhandari, Design of Machine Elements, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

Reference books:

- 1.Bansal, R.K., "Strength of Materials", Laxmi Publications (P) Ltd., 2007.
- 2.S.S Rattan, "Strength of Materials", Tata McGraw Hill, 2009.

Course code: 17VT404 Total Hours : 30 hrs	PRESS TOOL TECHNOLOGY-II	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to make the students : 1. Ability to design Progressive Tools. 2. Comparison between Progressive tool & compound tool. 3. Highlight the design aspect of bending tool. 4. Highlight the design aspect of deep drawing.				
Course out comes	Upon successful completion of this course, the trainee will be able to: 1. Explain the elements of compound tool. 2. Compare between Progressive tool & compound tool. 3. Describe the design aspect of deep drawing.				

Module 1

Compound Tool- Function of elements – Design of compound tool, Comparison of Progressive tool & Compound tool. Bending- Principals of bending, Plastic deformation due to bending, Bending elements.

05 Hrs

Module 2

Blank length – calculation of original length of strip required for bent component- formula for calculating- Developing the blank size, bending radius – calculation of maximum and minimum radius, bending force – bending force for “V” bending dies, bending force for “U” bending dies.

06Hrs

Module 3

Spring back – spring back in “V” bending dies. – Over bending- Corner setting- off set punch method angular punch relief, spring back in “U” bending dies- Remedies.

05 Hrs

Module 4

Stripping U bends – spring actuated plungers- hook strippers- positive knock off, Effects of grain direction on bending.- effects of burr side- bending in proximity to pierced holes, Materials for bending, Types of bending tools- elements- design- “V” bending dies- “U” bending dies- L bends on pressure pad dies- bending dies in press brakes- Rotary bending.

07 Hrs

Module 5

Deep drawing- Describe deep drawing- design of a draw tool, elements of draw tool, function of each element, Deep drawing of a cylindrical cup- explain, Force acting on a component

while drawing, Metal flow during drawing a cylindrical cup, Wrinkling and Puckering-differentiate wrinkling and puckering.**07 Hrs**

Text Books:

1. Tool Design – Donaldson
2. Die Design Fundamentals – Paquin

Reference Books:

1. Basic Die Making - Ostergarrd
2. Advanced Die Making – Ostergarrd
3. Tool Design - C.B Cole
4. Punches and Dies - Frank A Stanley
5. Fundamentals of Tool Design - A.S.T.M.E

Course code: 17VT406 Total Hours: 30 hrs	CNC TECHNOLOGY	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to make the students understand : 1. Familiarize with the technology of NC/CNC/DNC system. 2. Familiarize with the features of NC system. 3. Familiarize with the classification of NC system. 4. Awareness of the different elements of a numerically controlled machine tool. 5. Familiarize with NC/CNC machine tool.				
Course Outcomes	After successful completion of the course, the students should be able to: 1. Explain the technology of NC/CNC/DNC system. 2. Describe the features and classification of NC system. 3. Explain the different elements of a NC machine tool.				

Module 1

Familiarize with the technology of NC/CNC/DNC systems- History of NC, Growth of NC, NC / CNC / DNC: Introduction - Application - Advantages - Disadvantages - Development – Economy. **06Hrs**

Module 2

Features of NC system- Classification of NC based on Feed Back control system. Open loop control system-Closed loop control system, Classification Based on Motion Control System, Point to Point - Straight cut –Contouring.**06Hrs**

Module 3

Different elements of NC machine tool- Types of Spindle drive (AC & DC Servo Motor / Hydraulic) Special features of servomotor, Types of Axis Drive – stepper motor – servo motor, Features of stepper motor, Friction reducing elements, reciprocating ball bushes-Metallic and non-metallic guide ways-Spindle Bearing-Ball lead screw, Feedback devices. **06Hrs**

Module 4

Automatic Tool Changer, Automatic Pallet Changer, Automatic swarf removal mechanism, Tool and Work holding devices. Tool and tool material used in CNC machine tools- HSS cutting tools, Carbide tools -Solid Tool-Inserts, Other material.

06Hrs

Module 5

CNC part programming in FANUC control system-Milling- Axis nomenclature, Different Coordinate systems, Preparatory and Miscellaneous function codes used in FANUC control – Milling, Exercises on part programming – milling. **06Hrs**

Text Books:

1. Numerical machine tools- S.J Martin
2. Computers in manufacturing- George Schaffer

Reference Books:

1. The numerical controls of machine tool - Dr.Ing Wilhelm Simon
2. AM on Computers- American Machinist
3. Computer Technology- Eanle D Jones
4. CAD/CAM-Zimmers
5. Numerical controlled machines- KoramKuren
6. NC Machines and Cam- Pressman Williams.

Course code: 17VT412 Total Hours: 30 hrs	DESIGN THINKING & INNOVATION	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to enable students : 1. Introduce students to a discipline of design thinking that enhances innovation activities in terms of value creation, speed, and sustainability. 2. Understand the importance and phases of design thinking and innovation. 3. Examine approaches to innovation practiced by various organizations. 4. Understand the significance of Team Work and roles of individuals within a team.				
Course Outcomes	1. Apply the design thinking principles and recognize the significance of innovation. 2. Explain the importance of approaching innovation projects with concept development. 3. Discuss the need for and significance of adopting a design thinking mind set. 4. Develop creative ideas through design criteria & brainstorming sessions				

Module 1

Introduction to Design Thinking & Innovation: Design Thinking Phases, Scoping, Importance of storytelling. Design brief and visualization, Creativity and Idea Generation.

06 Hrs

Module 2

Scope of Design Process: Introduction, Steps of Design Process, Design Components, Requirements of a good product, Customer Satisfaction and Profitability.

06 Hrs

Module 3

Morphology of Design Process: Establishing design criteria, Creative Design & Engineering Design, Concept Development, Testing and Prototyping, Brainstorming & decision making.

06 Hrs

Module 4

Analysis of Design Problem: Design inputs and outputs, Constraints in Design, Tools for Preliminary Design, Market & Technology driven process.

06 Hrs

Module 5

Design Communication & Presentation: Types of design communications, Qualities of a Good Poster & Presenter, Barriers & Difficulties in Communication, Presentation Skills.

06 Hrs

Text Books:

1. C. L. Dym and Patrick Little, Engineering Design- A Project Based Introduction, John Wiley, 1995.
2. N. Cross, Engineering Design Methods: Strategies for Product Design, John Wiley, 1995.

Reference books:

1. Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation (Harper Business, 2009)
2. Bruce Hannington and Bella Martin, Universal Methods of Design: 100 Ways to Research Complex Problems, Develop Innovative Ideas, and Design Effective Solutions (Rockport Publishers, 2012)
3. Ian C. Wright, Design Methods in Engineering & Product Design, McGraw-Hill, 1998.
4. M. A. Parameswaran, an Introduction to Design Engineering, Narosa, 2004.

COURSE CODE :17VT407 HRS : 90	WORK SHOP-IV	L	T	P	S
		-	-	06	06
Course Objectives	The objective of this course is to enable students : 1. Able to understand the building of a bench fixture. 2. Able to cut thread on engine lathe 3. Able to cut left hand and right-hand thread 4. Able to cut different forms of thread. 5. Able to grind the end mill cutter 6. Able to file a bevel edge. 7. Able to do Profile filing.				
Course outcomes	Students after the completion of this course will be able to: 1. Work independently on manufacturing of elements such as Bench fixture, Base Plate, Handle, Guide Plate, Cam, Car Post and Bending Die. 2. Assembly of progressive tool.				

LIST OF EXPERIMENTS

1. **Manufacturing of elements-** Bench fixture, Base Plate, Handle, Guide Plate, Cam, Car Post and Bending Die. **20 hrs**
2. **Manufacturing of elements** – Spindle, Tool & Cutter, Try Square and Straight Edge. **20 hrs**
3. **Manufacturing of elements of Progressive Tool-** Guide bush and guide pillar. **20 hrs**
4. **Assembly of Progressive Tool** **30 hrs**

Course code: 17VT408 Total Hours: 90 hrs	TOOL DESIGN DRAWING-II FUSION 360	L	T	P	C
			-	06	06
Course Objectives	Students after the completion of this course will be able to: 1. Training in the ability to design Progressive Tools. 2. Training in the ability to design different types of Compound Tools. 3. Training in the ability to design different types of bending tools. 4. Training in the ability to design a Drawing tool. 5. Training in the ability to design a Hand injection mould.				
Course outcomes	Students after the completion of this course will be able to: 1. Design the Progressive tool. 2. Design the Compound Tool, bending tool and drawing tool. 3. Design an Injection mold.				

LIST OF EXPERIMENTS:

1. **Design of Progressive Tools-** Design a progressive tool with travelling stripper, design a progressive tool with side cutter and travelling stripper, design a progressive tool incorporating parting off operation. **20 hrs**
2. **Design of Compound Tools-** Design a compound tool with direct knock out mechanism, Design a compound tool with indirect knock out mechanism. **20 hrs**
3. **Design of Bending Tool-** Design a 'V' bending tool, design a 'L' bending tool, design a 'U' bending tool, design a 'Z' bending tool. **20 hrs**
4. **Design of Drawing Tool-** Design a draw tool with mechanical blank holding, Design a draw and pinch trim combination tool. **20 hrs**
5. **Design of Hand injection mould-** Design of a single cavity Hand Injection mould. **10 Hrs**

Course code: 17VT413 Total Hours: 30	Fundamentals of Python Programming Lab	L	T	P	C
		--	-	02	02
Course Objectives	The objective of this course is to enable students : The objective of this lab is to introduce students to the basics of Python programming. By the end of this lab, students should be able to write simple Python programs, understand basic programming concepts, and solve basic programming problems				
Course outcomes	Students after the completion of this course will be able to: Understand the fundamentals of programming. Write and execute Python programs. Use variables, data types, and basic operators. Implement control structures like if-else statements and loops. Create and use functions. Handle simple input/output operations. Gain confidence in solving basic programming problems using Python.				

1.	Introduction to Python (1 hour)	
	- Overview of Python and its importance. - Setting up the development environment (IDE installation).	
2.	Python Basics (2 hours)	
	- Printing and commenting in Python. - Variables, data types (integers, floats, strings), and type conversion.	
3.	Operators and Expressions (2 hours)	
	- Arithmetic, comparison, and logical operators. - Expressions and operator precedence.	
4.	Control Structures: Conditional Statements (3 hours)	
	- if, elif, else statements. - Logical conditions and boolean expressions.	
5.	Control Structures: Loops (4 hours)	
	- while loop and its use cases. - for loop and iterating over sequences.	
6.	Functions (4 hours)	
	- Defining functions and function syntax. - Parameters, arguments, and return values. - Scope and lifetime of variables.	
7.	Lists and Dictionaries (4 hours)	
	Creating and manipulating lists.	

	Introducing dictionaries and key-value pairs.
8.	Input/Output (3 hours)
	- Input from the user (input() function). - Output using print() function. - Formatting output.
9.	Problem Solving and Mini Projects (7 hours)
	- Implementing simple programs using the concepts learned. - Solving programming exercises and challenges. - Creating mini projects to apply knowledge.
10.	Review and Assessment (2 hours)
	- Recap of key concepts. - Practical assessment or quiz to evaluate understanding.

Course code: 17VT414 Total Hours: 90 hrs	INJECTION MOLD AND PRESS TOOL DESIGN USING CATIA	L	T	P	C
		-	-	04	04
Course Objectives	The objective of this course is to make the students understand : 1. Part modelling of Progressive Tool 2. Assembly of Progressive Tool 3. Part modelling of 2 plateinjectionmold 4. Assembly of 2 plateinjectionmold				
Course Outcomes	After successful completion of the course, the students should be able to : 1. 3D modelling and assembly of Progressive Tool and 2 plateinjectionmolds.				

LIST OF EXPERIMENTS

PRESS TOOL DESIGN

1. **Part modelling of Progressive Tool**- Top plate, Bottom plate, Punch back plate, Punch holder, Punch.
2. **Part modelling of Progressive Tool**- Stripper plate, Stripper back plate, die plate, die back plate, Die.
3. **Part modelling of Progressive Tool**- Strip guide spacer, Strip guide holder, Guide pillar, Guide bush.

INJECTION MOLD DESIGN

1. **Part modelling of 2 plate injection mold** - Top plate, Sprue bush, Cavity plate, Cavity insert, Locating ring, Guide pillar.
2. **Part modelling of 2 plate injection mold** – Bottom plate, Core plate, Core insert, Guide bush, Ejector plate, Ejector back plate, Spacer.
3. **Assembly of 2 plate injection mold** - Assembly of top half and bottom half.

Course code: 17VT411 Total Hours: 01	KANNADA LANGUAGE	L	T	P	C
		01	-	-	-
Course Objectives	The objective of this course is to enable students : 1. To understand the basic communication in Kannada language. 2. To impart and motivate them to learn the State Language with ease and confidence enabling for better communication skills				
Course outcomes	Students after the completion of this course will be able to: 1. To help them learn the basic and fundamental concept of prose. 2. To help them to impart the knowledge in Kannada language				

Modules:

Lesson 1: Introducing each other – 1. Personal Pronouns, Possessive forms, Interrogative words.

Lesson 2: Introducing each other – 2. Personal Pronouns, Possessive forms, Yes/No Type Interrogation

Lesson 3: About Ramayana. Possessive forms of nouns, objective question, Relative nouns

Lesson 4: Enquiring about a room for rent. Qualitative and quantitative adjectives.

Lesson 5: Enquiring about the college. Predicative forms, locative case.

Lesson 6: In a hotel Dative case defective verb.

Lesson 7: Vegetable market. Numeral, plurals.

Lesson 8: Planning for a picnic. Imperative, Permissive, hortative.

Lesson 9: Conversation between Doctor and the patient. Verb- iru, negation – illa, non – past tense.

Lesson 10: Doctors advise to Patient. Potential forms, no–past continuous.

Lesson 11: Discussing about a film. Past tense, negation.

Lesson 12: About Brindavan Garden. Past tense negation.

Lesson 13: About routine activities of a student. Verbal Participle, reflexive form, negation.

Lesson 14: Telephone conversation. Past and present perfect past continuous and their negation.

B.VOC FIFTH SEMESTER SYLLABUS

Coursecode:17VT501 Total Hours: 30 hrs	PRESS TOOL TECHNOLOGY-III	L	T	P	C
		02	-	-	02
CourseObjectives	The objective of this course is to enable the students : 1. Understand sheet metal processes for different press tool operations and estimate percentage of utilization and economy factor. 2. Identify the elements and working mechanisms of various press tools. 3. Design of press tools for automotive components. 4. Analyze the tools for Bending, Forming and Drawing operations.				
CourseOutcomes	Students after the completion of this course will be able to : 1. Explain the necessity of press tool for Manufacturing of Stage, Progressive, Bending and Compound tools 2. Analyze the design constraints in the given problem 3. Apply the design rule for designing and manufacturing of press tools 4. Design and Drafting of press tools for considering real time issues of Manufacturing, Testing and Assembly				

Module 1

Buckling of punches-Buckling theorem – problems - types of loads acting on punches-determining the size of punches.Deep drawing-Blank development of a cylindrical shells-necessity for determining the blank diameterfor the cylindrical shells - development of blank usingthe algebraic method - using graphical method.Drawing Force- Explain drawing force – method for calculating drawingforce for a cylindrical cup.Press capacity-Blank holding Force-calculation method for blank holding forceClearance- importance of clearance- formula to calculate clearance forDeep drawing-calculationDie Punch radius- importance of die and punch radius.

07 Hrs

Module 2

Press capacity-Draw beads- importance of draw beads- types of beadsAir vents- importance of air vents- methods of providingLubrication during deep drawing- importance- lubricants for specific press working applicationNumber of draws- height of the cup at each stage. Diameter at each stage- Consideration of d/D ratio- consideration of percentage reductionDrawing flanged components- determination of number of draws calculation.Metal flow in a rectangular shell - describe- blank development of rectangular shell using graphical method.Faults occurring deep drawing- faults on material, equipment and Design of tools - faults in maintenance and setting tools- remedies- necessity of annealing in between draws (intermediate annealing).Reverse draw- explainIroning- explain ironingEyelet drawing – describe eyelet drawing- calculation of number of draws

07Hrs

Module 3

Acceptance of tools in process capability-Explain term process capability of tools- chance cause and assignablecauseTolerance on components- characteristic to consider during design-special characteristics - USL & LSL and USL &UCL.Production run of tools – uninterrupted production run- record results of identifying sp. Characteristic. Calculate process capability in termsofCp&Cpk

06Hrs

Module 4

Tool failures-Determining factors of tool failures-slug jamming- press selection- “knife edge” error in designing die block and punch. Explain “slug pulling” and the remedies Breakage of die plates and repair-welding, stitching, nesting etc. Factors Effecting Tool Life Introduction, Elements of tool performance – wear of punch and die block- side wall finish- excessive wear- die block life calculation.

06Hrs

Module 5

Advanced multistage Tooling-Application and advantages in doing different types of operation in a single tool progressively

04 Hrs

TextBooks:

1. Die Design Fundamentals - Paquin
2. Tool Design - Donaldson
3. Basic Die Making and Advance Die making - Ostergarrd

ReferenceBooks:

4. Tool Design - C.B Cole

Coursecode:17VT502 Total Hours : 30 hrs	MOULD TECHNOLOGY-II	L	T	P	C
		02	-	-	02
CourseObjectives	The objective of this course is to make enable the students : 1. To understand the applicability of thermosets and thermoplastics 2. To identify various techniques for processing of plastics 3. To evaluate process parameters for plastic components 4. To apply the rheology of plastics for selection of materials				
Courseoutcomes	Upon successful completion of this course, the trainee will be able to: 1. Design and draw compression moulds for plastic products 2. Applying basic principles of design of transfer moulds. 3. Apply basic principles of injection moulding to identify moulding defects and rectifying it 4. Compare between compression and transfer moulding process on the basis of process variables.				

Module 1

Mould for internal under cuts and threads-Different methods used in moulding internal undercuts - form pin - straight action form pin - angled action form pins - split cores - split core with straight and angled action -side cores. Stripping internal under cuts. Mould for threaded components - Method used - Fixed thread core design. Stripping threaded components -Loose thread core-Unscrewing mould - rotating cavity -moulding for external threaded component.Multi-daylight mould-Differentiate between single daylight mould and multi-daylight mould.Underfeedmoulds - Function of under-feed mould - basic underfeedmould – operation cycle. Types of feed: Secondary sprue gate-Reverse taper secondary sprue -Undercut runner system -runner stripper plate design - design feature.Triple daylight mould - Identify triple daylight mould.

07Hrs

Module 2

Runner less mould-Describe Runner less mould - four types of nozzles used in Runner less mould.Hot runner mould - different types of hot runner units - Describe hotrunnermould -

different types of hot runner units. Injection moulding defects- Shot fills, flow marks, silver streaking, poor weld lines, voids, sink marks, warpage. Compression moulding- Compression moulding process- compression moulding procedure- mould temperature- press closing speed- degassing or breathing- final cure time. Compression mould: vertical flash/ horizontal flash designs.

07Hrs

Module 3

Transfer moulding- Transfer mould procedure- Advantages/disadvantages of it. Moulding cycle- tighter dimensional tolerances- insert moulding Pot transfer mould- Plunger transfer mould- Runner-Gate- Vents. Die casting. Process description – hot chamber process- cold chamber process. Process other than injection moulding of thermoplastics. Blow moulding- Thermoforming- Rotational Moulding- Extrusion- Calendaring

06Hrs

Module 4

Advanced Moulding Process- Assisted Injection Moulding (AIM) – Gas and Water, Reaction Injection Moulding (RIM), Multicolor Injection Moulding, Injection Moulding of Metals (MIM)

05Hrs

Module 5

Working of injection moulding of thermosets and Advantage and disadvantages of direct screw transfer moulds, Injection Compression – Principle and mould design aspects, Factors affecting Mould Service Life- Mould Design Mechanical design, Mould maintenance

05Hrs

Text Books

5. Introduction of injection mould design - Pye
6. All about Plastics - NI George

Reference Books

1. Die Moulds and Jigs - V. Vladimir
2. Plastic material & Process - Schwartz

Coursecode:17VT503 Total Hours: 30 hrs	PRODUCTION MANAGEMENT CONTROL	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to make enable the students: 1. To understand the evolution and revolution of business and industry and their classification. 2. To understand factors to be considered in the site location and plant lay out 3. To understand the importance of Production planning and control and its procedure. 4. To understand the material management, purchase organization, store keeping and inventory control.				
Course Outcomes	After successful completion of the course, the students should be able to : 1. To identify the elements of operations management and various transformation processes to enhance productivity and competitiveness. 2. To analyze and evaluate various facility alternatives and their capacity decisions, develop a balanced line of production & scheduling and sequencing techniques in operation environments. 3. To solve routing and scheduling problems 4. To summarize various aggregate production planning techniques.				

Module 1

Understanding Industry-Types of business organization: Private sector, Public sector, Joint sector, Commercial sector. Types of manufacturing industry: Continuous type, flow production Intermittent type, Example and advantage and disadvantage. Production management system- Introduction, Understanding on industrial time elements, Lead time, Throughput time, TAKT time, Cycle time

05 Hrs

Module 2

LAYOUT- Introduction and principles of Site selection of a factory, Factory layout (plant buildings), Plant Layout. Flow pattern-Factors governing flow pattern-flow systems: horizontal flow lines (five basic types) - vertical flow lines (six basic types). **05 Hrs**

Module 3

Production planning & control-Introduction, Definition, concept and procedure of Sales forecasting, Process planning, Dispatching, Routing.

05 Hrs

Module 4

Materials, purchase, stores and inventory management- Function and Objective of Material management, Purchase organization .Stores and store keeping-purpose of store keeping, duties of store keeper- store location- methods of storing- protection of stores- stock stacking system. ,Inventory control- inventory classification- objectives and how to achieve them – function of inventories- economic order quantity- ABC analysis. **07 Hrs**

Module 5

Production and productivity management techniques- Production and productivity:

Understanding production and productivity-measures to increase productivity. Quality control: inspection and quality control- kinds of inspection- statistical quality control (SQC) - sampling inspection- control charts and their applications. Quality circle (QC): what is quality circle- origin of quality circle- structure of quality circle. Operation of quality circle. “KAIZEN” – understanding “KAIZEN”- objectives of kaizen “POKA YOKE”- understanding. “KANBAN”- the “JUST IN TIME”; management system; introduction to kanban

08 Hrs

Text Books:

1. Industrial organization and management - Sundaramurthy
2. Fundamentals of business organization - Y K Bushan
3. Store keeping - Ananthakrishnan
4. Plant layout and material handling - G Chandrasakaran

Reference Books:

1. Factory organizations and principles of management - K Ahiya
2. Industrial engineering - M Ponnuswamy

Course code:17VT507 Total Hours: 60 hrs	WORKSHOP-V	L	T	P	C
		-	-	4	4
Course Objectives	The objective of this course is to enable students : 1. Understanding the concepts of different operations such as Bench work, milling and Turning. 2. Understanding the concepts of different operations such as surface grinding and cylindrical grinding.				
Course Outcomes	Students after the completion of this course will be able to: 1. Work independently on different operations such as Bench work, milling, Turning, surface grinding and cylindrical grinding.				

LIST OF EXPERIMENTS

1. **Manufacturing of elements of Hand Injection Mould** -Top Plate, Cavity plate, guide pillar.
2. **Manufacturing of elements of Hand Injection Mould** -Bottom plate, core plate, actuating rod.
3. **Manufacturing of elements of Hand Injection Mould** –stripper plate, core and assembly

Course code:17VT509 Total Hours: 30 hrs	ENVIRONMENTAL STUDIES	L	T	P	C
		01	-	-	-
Course Objectives	The objective of this course is to enable students : 1. Recognize concepts in environmental sciences 2. Demonstrate the understanding of the environment. 3. Demonstrate the knowledge of social responsibility				
Course Outcomes	Students after the completion of this course will be able to: 1. Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale. 2. Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment. 3. Demonstrate ecology knowledge of a complex relationship between predators, prey, and the plant community. 4. Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues.				

Module1:

Environment, Components of Environment Ecosystem- Types & Structure of Ecosystem, Balanced ecosystem Human Activities, Food, Shelter, and Economic and Social Security. Impacts of Agriculture and Housing Impacts of Industry, Mining and Transportation Environmental Impact assessment, Sustainable Development. **06Hrs**

Module2

Natural Resources, Water resources and Energy-Availability and Quality aspects, Water borne diseases and water induced diseases, Fluoride problem in drinking water Mineral resources, Forest Wealth Material Cycles, Carbon Cycle, Nitrogen Cycle and Sulphur Cycle. Energy: Different types of energy, Conventional sources and Non-Conventional sources of energy, Solar energy, Hydro electric energy, Wind Energy, Nuclear energy, Biomass and Biogas Fossil Fuels, Hydrogen as an alternative energy. **06Hrs**

Module3

Environmental Pollution and Global Environmental Issues- Water Pollution, Noise pollution, Land Pollution, Public Health Aspects. Global Environmental Issues: Population Growth, Urbanization, Land Management, Water and Waste Water Management. **06Hrs**

Module4

Air Pollution, Automobile Pollution and Waste Management - Definition, Effects, Global Warming, Acid rain and Ozone layer depletion, controlling measures. Waste Management, E - Waste Management and Biomedical Waste Management, Sources, Characteristics and Disposal methods. **06Hrs**

Module5

GIS, Environmental Acts and Regulations-Introduction to GIS & Remote sensing, Applications of GIS and Remote Sensing in Environmental Engineering Practices.

Environmental Acts and Regulations, Role of government, Legal aspects, Role of Non-governmental Organizations (NGOs), Environmental Education and Women Education.

06Hrs

Text Books:

1. Benny Joseph, “Environmental Studies”, Tata McGraw – Hill Publishing Company Limited, 2005.
2. R.J.Ranjit Daniels and JagadishKrishnaswamy, (2009), “Environmental Studies”, Wiley India Private Ltd., New Delhi.

Reference Books:

1. Raman Sivakumar, “Principals of Environmental Science and Engineering”, Second Edition, Cengage learning Singapore, 2005.
2. R Rajagopalan, “Environmental Studies – From Crisis to Cure”, Oxford University Press, 2005,
3. Aloka Debi, “Environmental Science and Engineering”, Universities Press (India) Pvt. Ltd. 2012.

CourseCode:17VT513 Total Hours :30 hrs	QUALITY MANAGEMENT SYSTEM	L	T	P	C
		2	-	-	2
CourseObjectives	The objective of this course is to make enable the students : 1. To understand of the laws, principles and phenomena in the field of quality management. 2. To adopt the theoretical and practical knowledge and skills in thefield of quality management. 3. To understand the usage of PDCA cycle. 4. To understand the seven old and new QC tools. 5. To understand the role of inspection in an industry.				
Courseoutcomes	Students after the completion of this course will be able to : 1. Evaluate the principles of quality management and to explain how these principles can be applied within quality management systems. 2. Identify the key aspects of the quality improvement cycle and to select and use appropriate tools and techniques for controlling, improving and measuring quality. 3. Critically appraise the organizational, communication and teamwork requirements for effective quality management 4. Critically analyze the strategic issues in quality management, including current issues and developments, and to devise and evaluate quality implementation plans				

Module 1

Introduction to Quality- Definition of Quality, Customer Expectations, Need for Quality, Effects of Poor Quality, Importance of Quality, Quality Gurus.

06 hrs

Module 2

Deming Quality Wheel (PDCA) and QC- Introduction to Deming Quality Wheel and, Seven basic QC tools, Seven new QC tools

06 hrs

Module 3

Core Tools-APQP, PPAP, SPC– Control charts, FMEA-Design and Process

06 hrs

Module 4

Inspection- Inspection plans, Stages of Inspection, Method of Inspection, Inspection reports

06 hrs

Module 5

Introduction to ISO Systems-Evolution of ISO standards, Introduction to QMS, Introduction to EMS, Introduction to OHSAS

06 hrs

Text books

1. Total quality Management - Dale H. Besterfield, Pearson, , Pearson Education
2. The Management and Control of Quality, CengageLearning -Evans's. James, Lindsay M. William ,

Reference books

1. Total Quality Management - H.LaI, Lt. Gen ,Wiley Eastern Limited, 1990 ,
Beyond Total Quality Management - Bounds Greg , McGraw

Coursecode:17VT514 Total hours: 30	AUTOMATION – PNEUMATICS AND HYDRAULICS	L	T	P	C
		2	-	-	2
Courseobjectives	The objective of this course is to makethe students : 1. Impart knowledge of various means of power transmission 2. Understand important Fluid properties 3. Knowledge on how compressed air is produced. 4. Ability to design basic pneumatic circuits 5. Ability to design basic hydraulic circuits 6. Awareness on Hydro-pneumatic systems				
Courseoutcomes	Students after the completion of this course will be able to : 1. Understand the purpose and applications of fluid power systems in various fields. 2. Recognize standard schematic symbols for common fluid power components. 3. Understand and troubleshoot basic fluid power, electro-hydraulic, and electro-pneumaticcircuits using schematic diagrams. 4. Understand the operation, application, and maintenance of common fluid powercomponents such as pumps, compressors, valves, cylinders, motors, rotary actuators,accumulators, pipe, hose, and fittings.				

Module 1

Pneumatic power and hydraulic power-Pneumatic power and hydraulic power: Application, advantages and disadvantages.Properties of fluid:Density, specific volume, specific weight, relative density, pressure atmospheric, gauge, absolute pressure,viscosity.Definitions and Principles of Hydrostatics, Hydro Dynamics and Gas Laws

04hrs

Module 2

Production of Compressed air: Characteristics of compressed air: positive characteristics and negative characteristics. Types of compressors: Positive displacement compressors – reciprocating piston compressor – diaphragm compressor - rotary piston compressor – two-axle screw compressor – roots blower - Flow compressors: axial flow compressor - radial flow compressor. Terms associated with compressor: delivery volume-theoretical - effective- working pressure-operation. Drives for compressors: electrical motor - IC engine. Cooling of the compressors: need - methods - cooling fins - fans - fresh water cooling. Regulation of compressors: no load regulation - low speed regulation - on/off regulation. Compressed air receiver: necessary of compressed air receiver - selection of compressed air receiver - delivery volume - pressure - drive - cooling method- regulation - determination of air receiver size

05hrs

Module 3

Preparation & distribution of compressed air: Compressed Air Preparation: Necessary for the preparation of compressed air - functions of suction filter - functions of intercooler and re-cooler - necessity of drying compressed air - drying process - absorption drying - adsorption drying - low temperature drying - functions of air filter - requirements of air filter - functioning of pressure regulators - with vent hole - without vent hole – functions of compressed air lubricator - functions of service unit (FRL). Distribution of compressed air: system of distribution of compressed air – criteria for selecting pipe diameter - flow volume - pipe length - pressure drop – working pressure - number of restrictions in the pipe line - pipe diameter calculation - pipe material - types of line and tube connectors

05hrs

Module 4

Pneumatic working elements - Pneumatic cylinders: constructional details and working of: SAC – diaphragm cylinder - rolling diaphragm cylinder - DAC - cylinders with end position. cushioning - cylinders with double sided piston rod - cylinders with double sided piston - tandem cylinder - multi-position cylinder - impact cylinder – rotary cylinder - constructional features of pneumatic. Cylinders - calculation for cylinders - piston force - air consumption. Pneumatic motors: characteristics of pneumatic motor - working of - sliding vane motor - gear motors - turbine motors. Pneumatic valves: constructional details and functioning of: directional valves - non-return valves - pressure control valves - shut off control valves - quick exhaust control valves - sequence control valves - time relay control valves - representation of pneumatic valves with symbols. Basic pneumatic circuits - Symbols used in pneumatics (ISO 1219/DIN 24300) - design of basic pneumatic circuits employing SAC - design of basic pneumatic circuits employing DAC - rigging up circuits

Module 5

Hydraulic working elements -Hydraulic pumps: Constructional details of gear pump - functions of gear pump. Hydraulic cylinders: constructional details and working of SAC-DAC with double piston rod- with end position cushioning - telescopic cylinders - tandem cylinder - determination of force developed by cylinders. Hydraulic motor: working of basic model of hydraulic motor - working of cam type axial piston motor. Hydraulic filters: functions of filter-air breather filter -suction line filter-pressure line filter-return line filter. Hydraulic valves: construction and functions of: pressure relief valve - directional valve - flow control. Valve - representation of various hydraulic valves with symbols. Basic hydraulic circuits-Symbols used in hydraulics (ISO 1219/DIN 24300) - design of basic hydraulic circuits employing DAC - design of basic hydraulic circuits employing DAC - rigging up circuits. Hydro-pneumatic systems -Principles of hydro-pneumatic systems- advantages – pressure converter - pressure intensifier - functions of feed units - functioning of hydraulic accumulators - functioning of hydraulic intensifier. Electro-pneumatic system. - Principles – advantages

06hrs

Module 6

Electro Hydraulics & Electro Pneumatics - Important basic terms, Characteristics of Industrial Hydraulics & Industrial Pneumatics, Comparison of Hydraulics Vs. Electrical, Electronics, Pneumatics and Mechanical, Applications of Hydraulics & Pneumatics. Control elements & Valves.

05 hrs

Text Books:

1. Fundamentals of pneumatic control Engineering (Text book) - Festo
2. Hydraulics Course for Vocational Training - Festo
3. ABCs of Pneumatic Circuits - HL Stewart JM Storer
4. ABCs of hydraulic Circuits - HL Stewart JM Storer
5. Fluid Mechanics and Hydraulics - Dr. Jagadish Lal
6. Fluid Mechanics - Streeter.

Reference Book

1. Introduction to Pneumatics - Festo
2. Principles and theory of Pneumatics - Trade Technical press
3. Pneumatic Control - Vogel-Vela
4. Hydraulic and Pneumatic Power for Production - Stewart

Course code:17VT515 Total Hours : 45 hrs	Automation – Pneumatics and Hydraulics Lab	L	T	P	C
			-	03	03
Course Objectives	The objective of this course is to make the students : 1. Familiar with hydraulic & pneumatic components required for developing circuits 2. Able to work on hydraulic and pneumatic Simulation / Rigging Circuits on Kit 3. Able to control Speed of DAC using Flow control valve 4. Able to actuate DAC using Dual pressure valve				
Course outcomes	Upon successful completion of this course, the trainee will be able to: 1. Demonstrate the working of basic components of hydraulic and pneumatic circuits 2. Control the speed of DAC using Flow control valve 3. Develop hydraulic & pneumatic circuits				

LIST OF EXPERIMENTS

1. Familiarization of Components
2. Simulation / Rigging Circuits on Kit
3. Direct actuation of SAC
4. Indirect actuation of SAC
5. Direct actuation of DAC
6. Indirect actuation of DAC
7. Actuation of DAC using Dual pressure valve (AND function)
8. Actuation of DAC using Shuttle valve (OR function)
9. Speed control of DAC using Flow control valve
10. Speed control of DAC using Quick exhaust valve

Hands-On-Training

Hydraulics lab:

Exercise 1 : Extending a cylinder by operating a push button

Exercise 2 : Signal storage by electrical self-locking, setting and resetting using a momentary-contact switch

Exercise 3 Mechanical locking by means of momentary-contact switch contacts

Exercise 4 Electrical locking by means of contactor contacts

Exercise 5 : Signal storage by means of contactor contacts

Pneumatics lab:

Exercise 1 : Direct and indirect control of a single-acting cylinder

Exercise 2 : Direct and indirect control of a double-acting cylinder with pushbutton

Exercise 3 : Signal storage by means of contactor contacts

Exercise 4: Controlling a double- acting cylinder, impulse valve, 2 push-buttons

Exercise 5 : Displacement dependent control of a double acting cylinder, impulse valve

Course code: 17VT516 Total Hours: 75hrs	Project Work -I	L	T	P	C
			-	05	05
Course Objectives	The main objective of the Project Work is for the students to learn and experience all the major phases and processes involved in solving “real life engineering problems”.				
Course Outcomes	Students must have acquired: 1. System integration skills 2. Literature survey 3. Conceptual selections 4. Documentation skills				

The project work shall be spread over in B.Voc V semester and B.Voc VI semester.

- The project work shall be somewhat innovative in nature, exploring the research bent of mind of the student. A project batch shall comprise of not more than four students.
- A candidate will continue the Project Work in B.Voc V semester (Stage - II) and submit a Project report at the end of Stage - II after approval of Committee.
- During Stage - II, the teams shall submit status report in addition to oral presentation before the Committee. The DC shall evaluate the project for internal marks based on the progress, presentations and quality of work.

The report generally contains:

- Cover
- Title page
- Certificate(s)
- Acknowledgements
- Abstract
- Contents page
- List of figures or Tables
- Introduction
- Literature survey

Course code:17VT517 Total Hours: 30 hrs	Introduction to Artificial Intelligence and Machine Learning	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to provide students with a foundational understanding of Artificial Intelligence (AI) and Machine Learning (ML) concepts. By the end of this course, students should be able to comprehend the basics of AI and ML, understand their applications, and recognize their significance in various fields.				
Course Outcomes	Students after the completion of this course will be able to: Define and differentiate between Artificial Intelligence and Machine Learning. Identify common AI and ML applications. Understand the basic components of a machine learning workflow. Recognize the ethical and societal implications of AI and ML. Gain an awareness of current trends and future prospects in AI and ML.				

Module 1: Introduction to AI and ML (6 hours)

- Definition and brief history of Artificial Intelligence.
- Differentiating between Artificial Intelligence and Machine Learning.
- Types of Machine Learning: Supervised, Unsupervised, Reinforcement Learning.
- **Common applications of AI and ML.**

Module 2: Machine Learning Basics (6 hours)

- Understanding the basic components of a machine learning workflow.
- Data collection, preprocessing, and feature engineering.
- **Overview of model training, validation, and testing.**
- Introduction to supervised and unsupervised learning.

Module 3: Supervised Learning (8 hours)

- Exploring labeled data, features, and labels.
- Regression: Linear regression, polynomial regression.
- Classification: Decision trees, k-nearest neighbors.
- Hands-on exercises and simple examples.

Module 4: Unsupervised Learning (6 hours)

- Introduction to clustering and dimensionality reduction.
- K-means clustering and hierarchical clustering.
- Principal Component Analysis (PCA).
- Real-world applications and use cases.

Module 5: Neural Networks and Future Trends (4 hours)

- Basic concepts of neural networks.
- Introduction to deep learning and its significance.
- Current trends in AI and ML: Natural Language Processing, Computer Vision.
- Ethical considerations and implications of AI.
- Discussion on future possibilities and challenges.

TEXT BOOKS :

- "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig

REFERENCE BOOKS

- "Machine Learning Yearning" by Ian Goodfellow, YoshuaBengio, and Aaron Courville

Course code: 17VT518 Total Hours: 90hrs	TOOL DESIGN DRAWING-III	L	T	P	C
		-	-	06	06
Course Objectives	The objective of this course is to enable students : 1. Ability to design injection mould base. 2. Ability to design injection moulds with various types of Ejection mechanisms 3. Ability to design injection moulds with split cavities. 4. Ability to design injection moulds with delayed opening. 5. Ability to design a mould using split core mechanism. 6. Ability to design a mould for internal threaded component.				
Course Outcomes	Students after the completion of this course will be able to : 1. Design various ejection mechanisms 2. Design mould using split cavities 3. Develop internal threaded components using mould design.				

LIST OF EXPERIMENTS

- Design of injection mould base
- Design of 2 plate injection mould
- Design of injection mould with sleeve ejection
- Design of injection mould with stripper plate ejection
- Design of split cavity injection mould with sleeve ejection
- Design of split cavity injection mould with dog leg cam.
- Design of mould with side core
- Design of mould with split cores - (angular acting)
- Design of moulds having threads. – Collapsible core
- Develop PLC-based control systems for manufacturing cells
- Study of various post processors used in NC Machines.
- Development of NC code for free form and sculptured surfaces using CAM packages
- Machining of simple components on NC lathe by transferring NC Code from a CAM package.

Textbooks:

- Die Design Fundamentals - ASTM
- Die Design Fundamentals - Paquin

B.VOC SIXTH SEMESTER SYLLABUS

Course Code: 16VT602 Total Hours: 30 hrs	Mould Technology III	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to: 1. Highlight the importance of mould Polishing. 2. Appreciate the factors effecting mould service life and Mould Maintenance. 3. Familiarize the design of injection molding of Thermosets. 4. Pass on awareness on different Surface treatment methods of Plastic. 5. Familiarization of the Die casting Die. 6. Familiarization of Flow systems of die casting. 7. Knowledge about the various Defects and remedies in die casting.				
Course Outcomes	Students after the completion of this course will be able to: 1. Work on the mould Polishing keeping the factors effecting mould service life and Mould Maintenance. 2. Work with die casting systems understanding the flow systems of die casting. 3. Use knowledge about the various defects and suggest remedies in die casting. 4. Familiarization of Metal injection molding. 5. Apply the skills of heat treatment on plastics.				

Module1:**03 Hrs**

Polishing: Importance of mould polishing, Importance of mould finishing – Chrome plating – advantages of chrome plating – practical hints – Sequence of lapping and polishing of mould parts. Factors effecting mould service life, Mechanical design – grade of tool steel – Machining procedure – heat treatment – grinding – handling. Mould maintenance – break down maintenance – Mould history card – Preventive maintenance based on wear due to moulding.

Module2**08 Hrs****Injection moulding of Thermosets plastics:**

Injection moulding of thermosets – describe the working of injection moulding of thermosets – Advantages and disadvantages of direct screw transfer moulds. Mould design – process of injection moulding of thermosets – mould heating – sprue – runner – gate – venting – condition of injection moulding of thermosets – counter pressure – injection pressure – hold on pressure – curing time.

Module3**03 Hrs****Surface Treatment of plastics:**

Screen printing, hot stamping, heat transfer decoration, two color moulding, electroplating of plastics, and vacuum metalizing of plastics.

Module4**03 Hrs**

Die casting: Die casting Die, Basic terminology- elements of mould, function, fixed half moving half impression cavity core ejector grid

Flow systems of die casting: Metal flow systems in die casting die – Machine suitability – the goose neck, the nozzle, sprue, runner systems, shock absorber, gate, air vents over flows.

Module5**04 Hrs****Defects and remedies of die casting:**

Cold type defects – reasons for the occurrence of two type's cold defects- remedies for avoiding, Hot type defects – reasons for the occurrence of five type's hot defects on a die cast component. – Remedies for avoiding, Miscellaneous defect – suggesting reasons and remedies for the six types of defects on the die cast component.

Plastic Product design guide line

Selection of product market need – prototype – confirm specification – consolidate design – manufacturing stage – quality parameters – validate the outcome – launch product. Injection moulding of metals, Introduction of MIM, MIM process & Applications of MIM parts.

Text Books:

1. Introduction of injection mould design - Pye
2. All about Plastics - NI George

Reference Books:

3. Die Moulds and Jigs - V. Vladimir
4. Plastic material & Process - Schwartz

Course Code: 16VT603 Total Hours: 30 hrs	Mould Technology III	L	T	P	C
		2	-	-	2
Course Objectives	The objective of this course is to enable students : 1. Highlight the importance of Estimation. 2. Highlight the importance of costing and constituents of estimate. 3. Determine the selling price of a component. 4. Familiarizing with all the steps in finding the basic machine hour rate. 5. Highlight the methods of estimating the tooling. 6. Familiarization of estimation guide. 7. Familiarize with the standard estimation sheet for the press tools 8. Work out estimates for jigs, fixtures, moulds and dies. 9. Work out cost of components.				
Course Outcomes	Students after the completion of this course will be able to: 1. Highlight the importance of Estimation. 2. Highlight the importance of costing and constituents of estimate. 3. Determine the selling price of a component. 4. Familiarizing with all the steps in finding the basic machine hour rate. 5. Highlight the methods of estimating the tooling. 6. Familiarization of estimation guide.				

Module1:**03 Hrs**

Importance of Estimation: Estimation – meaning-define, aims of estimating , Over and under estimation- identify , Quality of an estimator , Source of errors in estimation , Importance of costing & constituents , Meaning of costing- define , Aims of costing- explain , Constituents of estimates: design time- drafting time- planning and production design and arrangements of special items-, experimental work-material, labour – overheads. , Time allowances: set up time- operation time- tear down time-miscellaneous allowances

Module2**08 Hrs**

Selling price of a component: Elements of cost: direct material-indirect materials- direct labour- indirect labour-direct expense- indirect expense.

Components of cost: prime cost- factory cost- office cost- total cost- selling price, Numerical problems.

Module3**03 Hrs****Basic machine hour rate:**

Factors in finding basic machine hour rate capital cost- depreciation- interest on capital cost- energy cost- space cost- maintenance and servicing cost- scrap value,

Numerical calculations, Methods of estimating the tool , Rough method of estimation- advantages and disadvantages

Module4**03 Hrs****Estimation guide:**

Estimation guide for press tool: time for round punches-blanking in single stage- embossing in single stage- round holes in progressive tools- notching in progressive tools- bending in progressive tool Standard estimation sheet for press tools. Standard estimation sheet: basic die- basic tool-extra allowance-raw material cost- die set cost-design charges. Estimation of press tool: use of standard estimation sheet- arrive at a final cost- work out

Module5

04 Hrs

Estimate of moulds and dies:

Estimation for one jig and a Fixture

Injection mould estimate: simple single cavity injection mould- multi cavity injection mould- injection mould with side core. Compression mould estimation: single cavity – multi cavity ,Transfermould estimation , Pressure die casting estimation , Cost of component , Sheet metal: raw (weight norm) material cost- labour cost – amortization cost- extra expenses.

Moulded components: Raw material cost- shot weight(including runner and sprue)- labour cost- extra expenses , Machined and casted component

Text Books:

1. Mechanical estimation and costing - T.R. Banga& S.C. Sharma
2. Principles and practices of Book - V.A.Patil& Keeping J.S. Korlahalli

Reference Books:

1. Rahman's Cost and Management Accounting
2. 4 Nafeesbaig Problems of Management accounting.

Course Code: 16VT604 Total Hours: 30 hrs	Industrial Management	L	T	P	C
		2	-	-	2
Course Objectives	The objective of this course is to enable students : 1. To know the definitions and levels of management. 2. To understand the meaning of productivity. 3. To study the importance of quality circle. 4. To highlight the modern production management system. 5. To study the importance of Lean manufacturing 6. To know the definition of TQM/TPM. 7. To understand the industrial & factories act.				
Course Outcomes	Students after the completion of this course will be able to: 1. To know the definitions and levels of management. 2. To understand the meaning of productivity. 3. To study the importance of quality circle. 4. To highlight the modern production management system. 5. To study the importance of Lean manufacturing				

Module1: **03 Hrs**
BASICS OF MANAGEMENT :basics of management and functions , levels of management, role and responsibility , inspection and quality control , quality control inspection, 7 QC tools, , SQC and SPC,quality standards, ISO 9000 clauses and steps to implement ISO 9000

Module2 **08 Hrs**
ENVIRONMENTAL POLLUTION & INDUSTRIAL SAFETY:
Types of Pollution and Environmental issues,Environment Management System - ISO 14001,Losses due to Industrial Accidents,Direct& Indirect Losses,PreventiveMeasures,Safety Committee & Safety Management System(OSHAS 18001)

Module3 **03 Hrs**
MODERN PRODUCTION MANAGEMENT SYSTEM
5 S ,KAIZEN , KANBAN , POKA – YOKE, LEAN MANUFACTURING, Brief about TPS & 14 Principles of Toyota, , Definition of Lean, Lean thinking, 8 Waste of Lean Manufacturing and Common lean tools, JIT (JUST IN TIME) in lean and Lean Deployment

Module4 **03 Hrs**
TPM/TQM
TPM: Definitions & Descriptions of TPM
Benefits of Implementing TPM, TPM Model and 8 Pillars of TPM,Introduction to Overall Equipment Effectiveness (OEE)
TQM: TQM Overview and Principles of TQM, Cost of Quality and 6 Cs of Quality, 5 Core Tools, TQM Implementation

Module5 **04 Hrs**
HUMAN RESOURCES AND MANAGEMENT, INDUSTRIAL RELATIONS AND LEGISLATIONS
Recruitment Procedure, Training & Training Needs, Leadership, Team Building & Creativity
Employee's welfare facilities, Industrial relations-Industrial disputes, Trade union act-rights and Liabilities, Indian factories act, Payment of wages act, workmen's compensation act, ESI,PF act

Course Code: 16VT613 Total Hours: 30 hrs	Additive Manufacturing	L	T	P	C
		2	-	-	2
Course Objectives	The objective of this course is to enable students : 1. Understanding the basic functionalities of AM and major difference as compared to conventional subtractive / forming processes. 2. Introduce the main application of AM with focus on the pertinent time and cost advantages that are realizable 3. Understanding the seven different categories of AM processes in alignment with ASTM defined classification of AM processes 4. Understanding the functionalities of FDM and PolyJet processes including the important system specifications 5. Introducing various AM materials and their thermo-mechanical properties				
Course Outcomes	Students after the completion of this course will be able to: 1. Getting to know the pre-processing software of FDM / PolyJet systems 2. Sensitize the student to the effort involved in rendering the AM parts ready for application through various post processing means 3. Developing a consideration for part quality when prototyping the parts using AM 4. Developing insight into applications of AM parts in prototyping, tooling and direct use instances				

Module1:**03 Hrs****Introduction to AM Technologies:**

Additive manufacturing definition and characteristics, Differentiation from conventional manufacturing, AM process description and applications, Advantages and disadvantages of AM

Module2**08 Hrs****AM Technologies and Materials:**

Extrusion, Vat photo polymerisation, Binder jetting, Material jetting, Sheet lamination, Powder bed technologies, Directed energy deposition, Features of industry grade AM systems, Build parameters, Classification of AM materials (Plastics / metals / composites), Properties of AM materials

Module3**03 Hrs****CAD for AM:**

Moving from 2D to 3D, Fundamentals of meshing and STL format, Advanced CAD commands for AM, CAD data sharing, Introduction to CATALYST / INSIGHT software, Considerations for build speed / part strength

Module4**03 Hrs****Post Processing:**

Post processing methods and tools needed for post-processing, General fixing (voids, brown marks, sanding), Consideration of part quality (dimensional accuracy / surface finish)

Module5**04 Hrs****Applications of AM:**

Benefits and use cases for rapid prototyping, tooling and production parts, Design and prototyping of gear system, 3D printing of polyhedrons – verification of polyhedral formula, 3D printing of hollow objects – concepts of buoyancy, Sound printing, Key industries leading in AM applications - Aerospace / automotive / consumer goods / medical

Text books:

1. An introduction to 3D printing - Victoria Zukas, Jonas A Zukas
2. The 3D Printing Hand Book, (Technologies, Design and applications) - Ben Redwood, FilemonSchoffer, Brian Garret

Reference Books:

1. Additive Manufacturing Technologies -Ian Gibson, David W Rosen, Brent Stucker

Course code: 17VT606 Total Hours: 60 hrs	TOOL DESIGN DRAWING-IV FUSION 360				L	T	P	C
						-	4	4
Course Objectives	The objective of this course is to make the students understand : 1. Training in the ability to design a Compression mold. 2. Training in the ability to design a Transfer mold. 3. Training in the ability to design a Multi stage mold with positive pull mechanism. 4. Training in the ability to design a Die casting Die. 5. Training in the ability to design multi-function Progressive Tool.							
Course Outcomes	After successful completion of the course, the students should be able to : 1. Design all the elements of compression mold and transfer mold. 2. Design a die casting die and multi-function Progressive Tool.							

LIST OF EXPERIMENTS

- Design of compression mold-** Design of compression mold showing horizontal flash. design of compression mold showing vertical flash.
- Design of Transfer mold-** Design of a plunger transfer mold. Design of a pot transfer mold.
- Design of a Multi-Day Light mold-** Design of a triple day light.
- Design of Die casting die-** Design of a die casting die for a cold chamber system. Design of a die casting die for a hot chamber system.
- Design of an Advanced Multi stage Tool-** Design of a progressive tool with multiple operation- cutting,bending,and side cam piercingand parting.

Reference books:

1 Die Design Fundamentals - ASTME

2 Die Design Fundamentals - Paquin

Course code: 17VT607 Total Hours: 60hrs	WORKSHOP Practical –VI/3D printing LAB	L	T	P	C
Course Objectives	The objective of this course is to enable students : 1. Identify the parts of a 3D Printer and understand their function. 2. Load and unload the canisters on 3D Printer. 3. Prepare a 3D model in any CAD software for 3D printing 4. Prepare or convert 3D model in .stl format Use of 3D printing software for printing. 5. Select layer thickness according to the finish requirements, dimensional accuracy, function and/or total time to print. 6. Orient the model for economical and required strength requirements. 7. Print a model on 3D printing machine.				
Course Outcomes	Students after the completion of this course will be able to: 1. Develop a 3D model on computer using 3D software 2. Convert or prepare 3D model in. stl format 3. Prepare the print by proper orientation and selecting layer thickness 4. Print a part on 3D printer				

LIST OF EXPERIMENTS

1. **Machine(3D Printer-FDM) fundamentals** -Demonstrate Switching ON and OFF Printer, Demonstrate various parts and their functions, Familiarization of control panel functions on machine communication, Practice loading and unloading of canisters- for build material and support material, Demonstrate changing of printer heads, Demonstrate calibration of printer heads, Checking the readiness of the machine for printing, Demonstrate stabilizing of machine for printing, Learn how to specify a printer based on Technology, print size & volume, Understand general maintenance and preventive maintenance of printer

2. **Part Development**-Open any CAD software(eg: Fusion 360) and demonstrate the software operation for 3D modelling a part, Understand the importance of using the correct CAD format to manufacture a 3D printed part. Prepare 3D CAD models with tolerances and fitments requirements, Convert the 3D drawing into stl. Format, Examine the product for estimating the material requirement. Check the weight of the 3D model (say within 5grms), Demonstrate how to download a 3D models from internet, Demonstrate how to Convert other drawing formats in to stl for 3 D printing, Practice converting of other drawing formats into .
3. **3D Printing software** –Introduction to “Grab-CAD” software and other free software, Import the 3D model developed, Ensure weight of the 3D model within 5grms and select material – PLA, Understand slicing, support and density (infill option), Practice layer thickness selection based on finish & accuracy and calculate total time required to print, Know about minimum feature size , Selection of layer thickness with reference to the finish and dimensional accuracy required and material, Understand Honey comb structure.
4. **Part Printing**- Check the readiness of the machine for printing, Carry out additive manufacturing process on 3D Printer, Check the functionality of the product/desired output, Part Removal Procedures, Part inspection – Check the dimensional variations in all three axes with respect to the model dimensions.
5. **Post Processing**-Understand methods of post processing, Learn about joining methods of printed parts, Familiarize the application tools used for post processing, Learn about manual and soluble support materials, Removal of support materials

REFERENCE BOOKS

The 3D Printing Hand Book- Ben Redwood, Filemon Schoffer
An Introduction to 3D Printing- Victoria Zukas, Jonas A Zukas

Course code: 17VT608 Total Hours: 120 hrs	Project Work -II	L	T	P	C
			-	-	06
Course Objectives	The main objective of the Project Work is for the students to learn and experience all the major phases and processes involved in solving “real life engineering problems”.				
Course Outcomes	Students must have acquired: 5. System integration skills 6. Documentation skills 7. Project management skills 8. Problem solving skills				

- The project work shall be spread over in B.Voc V semester and B.Voc VI semester.
- The project work shall be somewhat innovative in nature, exploring the research bent of mind of the student. A project batch shall comprise of not more than four students.
- A candidate will continue the Project Work in B.Voc V semester (Stage - II) and submit a Project report at the end of Stage - II after approval of Committee.
- During Stage - II, the teams shall submit status report in addition to oral presentation before the Committee. The DC shall evaluate the project for internal marks based on the progress, presentations and quality of work.

The report generally contains:

- Cover
- Title page
- Certificate(s)
- Acknowledgements
- Abstract
- Contents page
- List of figures or Tables
- Introduction
- Literature survey
- Methodology
- Results and Discussion
- Conclusion and scope of future work.
- Reference list / Bibliography
- Appendices.

Avoiding plagiarism

1. Plagiarism is taking the words, theories, or ideas of another person and passing them off as your own.
2. Plagiarism can be copying inadvertently/advertently a passage from a book or journal or pasting something from the internet into report without referencing the original source.
3. Plagiarism can also result from wrong referencing.

Avoiding plagiarism

The guide/supervisor shall certify that the report is checked for plagiarism and is within 25% of the content.

Coursecode:17VT611 Total Hours: 30 hrs	LEAN MANUFACTURING SYSTEMS	L	T	P	C
		02	-	-	02
CourseObjectives	The objective of this course is to make the students The students shall be able to: 1. Understand the practices of lean manufacturing in Toyotaproductionsystem. 2. Analyze the various processes inorganizations. 3. Develop lean manufacturing strategies for improvingvariousprocesses. 4. Implement lean manufacturing principles indifferentorganizations.				
CourseOutcomes	Uponsuccessfulcompletionofthiscourse,thetraineewill beableto: 1. Understand the concepts of lean manufacturing 2. Implementand analyze lean manufacturingprinciples				

Module 1

IntroductiontoLeanManufacturing: DefinitionofLean,LeanandJust-in-Time,Sevenmajortypesofnon-value-addingwastesinmanufacturingprocesses-Overproduction, queues, transportation, inventory, motion, over processing and defectiveproduct.

06Hrs

Module 2

Toyota Production System (TPS): Origins, Underlying principles to TPS-Customer-supplier connection-product and service flows, results of Toyota Production System,Timeline.

06Hrs

Module 3

Key Lean Manufacturing Techniques: 5S-examples-benefits and drawbacks, SingleMinuteExchangeofDies (SMED) -examplesandbenefits,Kanban-examplesandbenefits, Cellular Manufacturing- examples and benefits.

06Hrs

Module 4

InventoryandVariation:Background,NeedoftheInventory,disadvantagesofInventory, Make-to-Stock versus Make-to-Order Production Systems, The Philosophy and Objectives, Foundation of Quality Control, Quantity Control case study.

06Hrs

Module-5

Planning and Goals: Hoshin–Kanri Planning, importance of Goals and Goal Deployment, Policy Deployment, Leadership in Goal Development and Deployment Sustaining the Gains: Importance of Sustaining the Gains, existence of Process gains and loss. **06Hrs**

Reference Books:

1. Lonnie Wilson, “How to Implement Lean Manufacturing”, McGraw-Hill, 2009 Edition, ISBN: 978-0-07-162508-1,
2. Michael Hammer & James Champy, “Reengineering the Corporation, A Manifesto for Business Revolution”, Harper Business Essentials, 2006 Edition, ISBN-978-0060559533
3. Jeffrey K. Liker, “The Toyota Way”, The McGraw-Hill, 1st Edition, 2004, ISBN-13: 978- 0070587472.
4. M.G. Korgaonker, "Just In Time Manufacturing", Macmillan India Ltd., 2006 Edition, ISBN: 0333 926633. C

Course code: 17VT614 Total Hours: 60hrs.	Automation- Digital Manufacturing PLC Lab	L	T	P	C
		-	-	04	04
Course Objectives	The objective of this course is to enable students : 1. To draw the 3D part modeling and assembly. 2. To do generative design for effective weight reduction. 3. To conduct basic analysis using ANSYS.				
Course Outcomes	1. Design, develop and manufacture sophisticated parts and assemblies using precision manufacturing processes. 2. Generate the alternative models using generative design to reduce the material wastage and weight of the material used with the same strength and properties. 3. Analysis of the models using Ansys and PLC software. 4. 3D printing of the parts done using Autodesk Fusion 360 software.				

LIST OF EXPERIMENTS

- Introduction to Autodesk fusion 360 software 05 Hours
- Sketching 2D drawings using Autodesk Fusion 360 05 Hours
- 3D part modelling using Autodesk Fusion 360 05 Hours
- Generative Design using Autodesk Fusion 360 10 Hours
- Assembly of the part modelling using Autodesk Fusion 360 05 Hours
- Convert the designed 3D model into an STL file 05 Hours
- Design analysis using ANSYS: Structural and Thermal analysis 10 Hours
- 3D printing of basic model done using Autodesk Fusion 360 05 Hours
- Introduction to PLC 05 Hours
- Simple construction of PLC Program. 05 Hours

TEXT BOOK

- Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing- Brent Stucker, David Rosen, and Ian Gibson

REFERENCE BOOK

- Smart Digital Manufacturing- Rene Wolf, RaffaelloLepratt

Course code: 17VT615 Total Hours: 30hrs	AUTOMATION – DIGITAL MANUFACTURING	L	T	P	C
		02	-	-	02
Course Objectives	The objective of this course is to enable students : Student should be able to Understand the function of PLC Understand I/O devices• Understand Timer, Counter, Intermediate, and Data Handling functions• Program the PLC with a ladder diagram• Understanding the basic functionalities of embedded systems•& IOT. Familiarization with industrial robots and their application.• To get knowledge about different types of manipulators.•				
Course outcomes	Students after the completion of this course will be able to: the PLC with a ladder diagram• Understanding the basic functionalities of embedded systems•& IOT. Familiarization with industrial robots and their application.• To get knowledge about different types of manipulators.•				

MODULE-1

INTRODUCTION TO PLC

Introduction, Block Diagram, Advantages and Disadvantages, PLC Basic Programming Procedure and I/O Devices Relation between Digital Gates and Ladder Logic Timer Functions Counter Functions,

MODULE-2

Introduction to HMI,

Data Handling with HMI, Communication Protocol Advantages and Applications of HMI.

MODULE-3

Introduction to SCADA,

Role of SCADA in Automation, Basic Components and Architecture of SCADA , Types of SCADA System, Applications of SCADA ,HMI and SCADA

MODULE-4

Robotics

Definition of Robot, Benefits of Robot, Laws of Robotics, Selection of Robot
Anatomy of Robots, Parts of Robot, Links and Joints, Arm and Wrist Configuration
End Effector – Grippers and Types, Applications of Robots - Industrial Applications – Material handling, assembling, Inspection, Drilling, Painting and Welding.

MODULE-5

IoT and Industry 4.0

Basics Definition ,Basic terminologies used in IoT , Components of IoT
Architecture of IoT ,Industrial IoT – Process, Advantages & Applications
Introduction to Industry 4.0 ,Building Blocks of Industry 4.0 and Technology Trends in Industry 4.0 ,Applications and Benefits

TEXT BOOKS:

ProgrammableLogicControllers:PrinciplesandApplications-
John.W.Webb,Ronald.A.Reis

IntroductiontoProgrammableLogicControllers–Dunning
ProgrammableControllersTheoryandImplementation-L.A.Bryan
ProgrammableLogicControllers -FrankDPetruzella

REFERENCE BOOKS:

ProgrammableLogicControllers:IndustrialControl-Khaledkame
IntroductiontoRobotics:MechanicsandControl -John.J.Craig-
PearsonEducationIndia.
Embedded/Real-TimeSystems:Concepts,DesignandProgramming-K.V.K.PrasadDream
techPress TheInternetofThings-SamuelGreengard

Course code: 17VT616 Total Hours: 30 hrs.	Non Destructive Testing	L	T	P	C
		02	-	-	02
Course Objectives	To introduce the basic principles, techniques, equipment, applications and limitations of NDT methods • To enable selection of appropriate NDT methods. • To identify advantages and limitations of nondestructive testing methods • To make aware the developments and future trends in NDT.				
Course Outcomes	The students will be able to differentiate various defect types and select the appropriate NDT methods for the specimen.				

Module -1

Introduction to NDT, Comparison between destructive and NDT, Importance of NDT, Scope of NDT, difficulties of NDT, future progress in NDT, economics aspects of NDT, Visual Inspection: tools, applications and limitations - Fundamentals of visual testing: vision, lighting, material attributes, environmental factors. 06 Hrs

Module-2

Liquid Penetrant Inspection: principles, properties required for a good penetrants and developers
 - Types of penetrants and developers and advantages and limitations of various methods of LPI
 - LPI technique/ test procedure applications, advantages and limitations
 06 Hrs

Module -3

Magnetic Particle Inspection (MPI)- Principles of MPI, basic physics of magnetism, permeability, flux density, cohesive force, magnetizing force, retivity, residual magnetism
 Interpretation of MPI, indications, advantage and limitation of MPI.

Module-4

Ultrasonic Testing (UT): principle, types of waves, frequency, velocity, wavelength, reflection, divergence, attenuation, mode conversion in ultrasonic UT testing methods contact testing and immersion testing, normal beam and straight beam testing, angle beam testing, dual crystal probe, ultrasonic testing technique

Module-5

Radiography Testing (RT): Principle, electromagnetic radiation sources: X-ray source, production of X-rays, high energy X-ray source, gamma ray source - Properties of X-rays and gamma rays, Eddy Current Testing (ECT) - Principle, physics aspects of ECT like conductivity, permeability, resistivity, inductance, inductive reactance, impedance

Text book •

Baldev Raj, Practical Non – Destructive Testing, Narosa Publishing House ,1997

Reference books

1. Hull B. and V.John, Non-Destructive Testing, Macmillan,1988
2. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, SpringerVerlag, 1990

Course code: 17VT617 Total Hours: 30hrs	PRODUCT DESIGN & MANUFACTURING	L	T	P	C
		2	-	-	2
Course Objectives	The objective of this course is to enable students : Student should be able to 1. To expose the students the basics of product design and manufacturing 2. To introduce students to the basic principles and evaluation methods of various aspects of designing components 3. To teach students about the Industrial manufacturability requirements 4. To provide knowledge about emerging technologies such as additive manufacturing, 3D scanning to perform reverse engineering and benchmarking.				
Course outcomes	Students after the completion of this course will be able to: 1. Explain the product life cycle phases and appropriate strategies 2. Construct product planning and specification documents 3. Choose an appropriate manufacturing process for product prototyping				

Module 1

Introduction, Characteristics of successful product development, Design and development of products, duration and cost of product development, challenges of product development. Asimow's Model - Product design practice in Industry - Strength consideration in product design. Product Life Cycle & Strategies at different stages - Case Studies. **06**

Hrs

Module 2

Product Planning: product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Product design morphology, Visual Design, and Quality Function Deployment (QFD). Product Specifications: specifications, specifications established, establishing target specifications, setting the final specifications, Case Studies. **06 Hrs**

Module 3

Product Architecture: Product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Assessing the need for industrial design, impact of industrial design, industrial design process, managing industrial design process and assessing quality of industrial design, Case Studies. **06 Hrs**

Module 4

Design for X (DF-X): (X=Manufacturing & Assembly, Maintenance, Safety, Environment, Quality. Estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Design for Production: Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, Design for PM Parts, Approach to Design with Plastics, Rubber, Ceramics. Case studies. **06 Hrs**

Module 5

Prototyping basics, principles of prototyping, technologies, planning for prototypes, advantages and applications. Rapid Prototyping: Two-Dimensional Layer, Techniques- Stereo lithography (SL), Solid Foil Polymerization (SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC). Reverse Engineering, Case Studies. **06 Hrs**

Text Books:

1. A C Chitale and R C Gupta, Product Design and Manufacturing -, PH1, - 3rd Edition, 2003
2. Amitabha Ghosh, - Rapid Prototyping-A Brief Introduction, Affiliated East West Press Pvt. Ltd., 1997.

Reference Books:

1. Karl. T. Ulrich, Steven D Eppinger, Product Design and Development - McGraw Hill - 2000.
2. Tim Jones, Butterworth Heinmann, New Product Development - Oxford. UCI -1997
3. GeofferyBoothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly -2002

Course code:17VT618 Total Hours: 30hrs	ADVANCED MOLD TECHNIQUES	L	T	P	C
		2	-	-	2
Course Objectives	The objective of this course is to enable students : Student should be able to 1. Understand the techniques for manufacturing of plastic components 2. Outline the significance of blow molding and RIM. 3. Analyze components of extrusion coating. 4. Understand the concept of PTFE molding.				
Course outcomes	Students after the completion of this course will be able to: 1. Understand Injection molding, Extrusion, Lamination, Blow molding and special molding techniques. 2. Analyze the plastic components and challenges in selection of feed system. 3. Apply the engineering knowledge for the selection of type of mould for plastic components. 4. Design and evaluate the effects of mold on the components.				

Module1

Future trends in injection molding-Molding of cellular product like EPS, steam chest molding, future trends in injection molding like external & internal inter locking alignment of large molds, processing of specialty polymers.

06Hrs

Module 2

Blow Molding-Working principle of blow molding machine, injection stretch blow molding of PET, precut molding, multi-layer blow molding.

06Hrs

Module3

Reaction Injection Molding and LSR molding-RIM of Polyurethane, material for RIM, liquid RIM & its advantages over conventional injection molding. LSR-process,

equipment, characteristics of LSR, advantages of LSR.

06Hrs

Module4

Lamination-Lamination by extrusion coating, twin screw extrusion, co-rotating & counter rotating, feeding mechanism in twin screw extruder, principles of compounding, mixing mechanism etc.

06Hrs

Module 5

PTFE Molding-Processing techniques used for PTFE, Material consideration, sintering, Ram extrusion and Paste extrusion, advantages of PTFE processing.

06Hrs

Text Books:

1. Injection Moulding, Theory and Practice by Irvin I. Rubin. Wiley-Interscience, ISBN-13: 978-0471744450
2. Extrusion Die Design, M. V. Joshi. Publisher Macmillan Publishers India Ltd ISBN-13: 9780333904497
3. Polymer Extrusion 5E, Rauwendaal, C. New York, Hanser Publications ISBN: 9781569905166
4. Blow Molding Handbook: Technology, Performance, Markets, Economics: The Complete Blow Molding Operation, Dominick V. Rosato, Hanser Gardner Publications (ISBN13: 9781569903438)2003.