

DAYANANDA SAGAR UNIVERSITY
SHAVIGE MALLESHWARA HILLS, KUMARASWAMY LAYOUT
BENGALURU-560 111, KARNATAKA.

SCHOOL OF ENGINEERING



SCHEME & SYLLABUS
FOR
BACHELOR OF TECHNOLOGY (B.Tech.) - 2021

AEROSPACE ENGINEERING

(ASE) – V & VI SEMESTERS

2021-22 Onwards

SCHEME - B. TECH

V SEM - AEROSPACE ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	J	C	SEM	COURSE CODE
1	101	21AS3501	AERODYNAMICS - II	CR	03	--	--	--	03	*	***
2	101	21AS3502	DRIVES AND ACTUATORS (New course introduced)	CR	02	--	02	--	03	*	***
3	101	21AS3503	AIRCRAFT PERFORMANCE	CR	03	--	--	--	03	*	***
4	101	21AS3504	INTRODUCTION TO SPACE TECHNOLOGY	CR	03	--	--	--	03	*	***
5	101	21AS35XX	PROFESSIONAL ELECTIVE COURSE – I	CR	03	--	--	--	03	*	***
6	101	21AS3505	MODEL BASED SYSTEM ENGINEERING (MBSE)	CR	02	--	02	--	03	*	***
7	101	21AS3506	INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS	CR	02	--	02	--	03	*	***
8	101	21AS3507	FLIGHT PHYSICS LAB	CR	--	--	02	--	01	*	***
					18	--	08	--	22		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, J - Project, C – No. of Credits,

Professional Elective Course – I

Sl. No	Course Code	Course Name
1	21AS3508	WIND TUNNEL TESTING
2	21AS3509	AIR TRANSPORTATION SYSTEM
3	21AS3510	NPTEL

Open Elective:

Course Code	Course Name
21OE0023	INTRODUCTION TO AEROSPACE ENGINEERING

SCHEME - B.TECH
VI SEM - AEROSPACE ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	J	C	SEM	COURSE CODE
1	101	21AS3601	AVIONICS	CR	02	--	02	--	03	*	***
2	101	21AS3602	ORBITAL MECHANICS	CR	03	--	--	--	03	*	***
3	101	21AS3603	CONTROL SYSTEMS	CR	03	--	02	--	04	*	***
4	101	21AS3604	AIRCRAFT STABILITY AND CONTROL	CR	03	--	--	--	03	*	***
5	101	21AS3605	INTRODUCTION TO FINITE ELEMENT ANALYSIS	CR	02	--	02	--	03	*	***
6	101	21AS36XX	PROFESSIONAL ELECTIVE COURSE – II	CR	03	--	--	--	03	*	***
7	101	21OEXXXX	OPEN ELECTIVE – I	CR	03	--	--	--	03	*	***
8	101	21AS3606	SKILL ENHANCEMENT COURSE – (AEROSPACE SYSTEMS DESIGN AND MODELLING)	CR	00	--	02	--	01	*	***
					19	--	08	--	23		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, J – Project, C – No. of Credits,

Professional Elective Course –II

Course Code	Course Name
21AS3607	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING (New course introduced)
21AS3608	UNMANNED AIRCRAFT SYSTEMS
21AS3609	DIGITAL MANUFACTURING

Open Elective

Course Code	Course Name
21OE0049	INTRODUCTION TO SPACE TECHNOLOGIES
21OE0050	SATELLITE TECHNOLOGIES (New course introduced)

AERODYNAMICS II

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

SEMESTER – IV

Course Code	: 21AS3501	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. Derive the governing equations of compressible fluid flow.
2. Explain the characteristics of normal and oblique shock waves and expansion waves.
3. Analyze high-speed aerodynamics and its effects on the design and operation of aircraft.
4. Understand the measurements of fluid properties and calculate aerodynamic coefficients in high-speed flows.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teachers 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, note taking, annotating, and roleplaying.
3. Show **Video/animation** films to explain the 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.

Course Content

UNIT – I

06 Hours

One-Dimensional Compressible Flow:

Basic concepts of compressible flow continuity, energy and momentum equations. One dimensional inviscid flow; Stagnation quantities; Isentropic conditions. Speed of sound and Mach number; Isentropic relations; Area-velocity relation, Area Mach number relation.

UNIT – II

10 Hours

Normal Shock Waves and Flow through Ducts:

Normal shock waves: Rankine – Huguenot relations, Flow through the convergent-divergent nozzle, and Performance under various back pressures.

Flow through constant area duct with friction (Fanno flow) and Flow through constant area duct with heat addition (Rayleigh flow).	
UNIT – III	08 Hours
Oblique shocks and Expansion waves: Oblique shock relations, Supersonic flow past wedges and cones, strong, weak and detached shocks, Shock-interactions and reflections. Flow past convex corners, Prandtl –Meyer expansion, Shock Expansion Theory- Application to supersonic airfoils.	
UNIT – IV	08 Hours
Steady State Compressible Flows: Basic potential equations for compressible flow, Linearization of potential equation-small perturbation theory, Linearised supersonic flow, linearised supersonic pressure coefficient, application to supersonic airfoils, Lift, drag and center of pressure of supersonic profiles.	
UNIT – V	07 Hours
Measurements in High-Speed Flow: Types of subsonic and Supersonic wind tunnels - characteristic features, their operation and performance. Shock tubes and shock tunnels - Free flight testing - Measurements of pressure, velocity and Mach number –Flow visualization methods of subsonic and supersonic flows.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Use isentropic relations to analyze compressible flow through variable area ducts.	L2 & L3
2	Calculate flow properties across a normal shock wave using Rankine-Hugoniot relations.	L2 & L3
3	Solve for compressible flow characteristics with friction and heat transfer.	L2 & L3
4	Analyze oblique shock waves and expansion waves and determine the flow properties across these wave for flow over cones and wedges.	L3 & L4
5	Determine aerodynamic coefficients in supersonic flows	L3 & L4
6	Compare the working of wind tunnels and shock tunnels under various flow conditions.	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	3
C01	3	3			2								3		
C02	3	3			2								3		
C03	3	3			1								2		
C04	3	2			2								2		
C05	3	3		2	1					1			3	2	
C06	3	2			1					1			2		

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. John D Anderson, "Fundamentals of Aerodynamics", Mc Graw Hill, 6th edition, 2017, ISBN 978-1-259-12991-9.
2. Ethirajan Rathakrishnan., "Gas Dynamics", Prentice Hall of India, 5th edition, 2014, ISBN-13: 978-8120348394

REFERENCE BOOKS:

1. John D Anderson, "Modern Compressible Flow", Mc Graw Hill, 3rd edition, 2012, ISBN-13: 978-1259027420.
2. Ethirajan Rathakrishnan., "Applied Gas Dynamics", John Wiley & Sons Ltd, 2nd edition, 2019, ISBN 9781119500452
3. Ascher. H. Saphiro, "Dynamics and Thermodynamics of Compressible fluid flow", John Wiley & Sons, 1st edition, 1977, ISBN-13: 978-0471066910.
4. Yahya, S.M., "Fundamentals of Compressible flow", NEW AGE, 2009, ISBN-13: 978-8122426687.
5. H.W. Liepmann and A. Roshko, "Elements of Gas Dynamics", Dover Publications Inc, 2003, ISBN-13: 978-0486419633.

E-Resources:

1. <https://nptel.ac.in/courses/112103021>
2. <https://nptel.ac.in/courses/101106044>

Activity-Based Learning (Suggested Activities in Class)

1. Use of online calculators/software to calculate isentropic properties, normal and oblique shock relations, aerodynamic coefficients and flow visualization (<https://devenport.aoe.vt.edu/aoe3114/calc.html>, <https://www.grc.nasa.gov/www/k-12/rocket/ieisen.html>).
2. Demonstration of the solution to a problem through programming.

DRIVES AND ACTUATORS

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

SEMESTER – IV

Course Code	: 21AS3502	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 + 26 Hours
L-T-P	: 3-0-2		

Course Learning Objectives:

This Course will enable students to:

1. **Analyze** the hydrostatic laws for fluid power systems
2. **Explain** the drives and actuators.
3. **Understand** hydraulic and pneumatic systems.
4. **Analyze** the hydraulic and pneumatic 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.

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

08 Hours

INTRODUCTION:

Introduction to Fluid power, Advantages and Applications, Fluid power systems, Types of fluids, Properties of fluids and selection, Basics of Hydraulics, Pascal's Law, Principles of flow, Friction loss, Work, Power and Torque Problems, Sources of Hydraulic power: Pumping Theory, Pump Classification, Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary, Fixed and Variable displacement pumps.

UNIT – II

08 Hours

Module -2: Aircraft systems Aircraft Hydraulic & Pneumatic Systems Components of a typical Hydraulic system, Working of Hydraulic system, Power packs, Hydraulic actuators. Aircraft, Landing gear and Wheel Braking and Anti-Skid & Shimmy System. Pneumatic system and its components	
UNIT – III	06 Hours
MODULE -3: HYDRAULIC ACTUATORS AND CONTROL COMPONENTS Hydraulic Actuators: Cylinders, Types and construction, Application, Hydraulic cushioning , Hydraulic motors, Control Components : Direction Control, Flow control and pressure control valves, Types, Construction and Operation, Servo and Proportional valves, Applications	
UNIT – IV	09 Hours
Module -4:PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS Properties of air, Perfect Gas Laws, Compressor, Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Cascade method, Electro Pneumatic System, Elements, Ladder diagram, Introduction to fluidics and pneumatic logic circuits	
UNIT – V	08 Hours
MODULE -5: HYDRAULIC AND PNEUMATIC CIRCUITS Design of hydraulic and Pneumatic circuits, Accessories : Reservoirs, Pressure Switches ,Applications	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Classify fluid power systems and apply Pascal law to determine the pressure variation.	L2 & L3
2	Apply the hydrostatic law with respect to design of hydrostatic circuits.	L2 & L3
3	Analyze hydraulic and pneumatic systems in a aircraft.	L2 & L3
4	Apply the hydrostatic and pneumatic laws to design the circuits.	L2 & L3
5	Evaluate the performance of single and double acting cylinders, pneumatic switches,	L3 & 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	3
C01	3	3											1		
C02	3	3			1								1		
C03	3	3			1				3	3			1		
C04	3	3											1		
C05	3	3											1		
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)					

TEXT BOOKS:

- 1) Hydraulics and Pneumatics: A technician's and engineer's guide ; Author, Andrew Parr ; Edition, revised ; Publisher, Elsevier, 2013
- 2) Cengel, Y. A., Cimbala, J. M., "Fluid Power with Applications", 2nd Ed., Tata McGraw Hill, 2010

REFERENCE BOOKS:

1. P.N. Modi and S.M. Seth (1999), "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, Naisarak, Delhi

E-Resources:

3. <https://archive.nptel.ac.in/courses>

BASIC & ELECTRO HYDRAULICS, PNEUMATICS Total Contact Hours: 26

Following are experiments to be carried out using either C programming language or Object-oriented programming language:

- 1) Extending a cylinder by operating a push button
- 2) Signal storage by electrical self-locking, setting and resetting using a momentary-contact switch
- 3) Mechanical locking by means of momentary-contact switch contacts Exercise 4 Electrical locking by means of contactor contacts
- 4) Signal storage by means of contactor contacts Accumulator, applications
- 5) Pressure switches and proximity switches Exercise 8 : Advance control with time-dependent intermediate stop
- 6) Direct and indirect control of a single-acting cylinder, double-acting cylinder with pushbutton
- 7) Signal storage by means of contactor contacts, Holding-element control of a double-acting cylinder with impulse valve, directly controlled
- 8) Displacement-dependent control of a double-acting cylinder, impulse valve, cylinder switch
- 9) Sequential control of 2 double-acting cylinders with impulse valves and signal overlapping spring return valves and step sequence.

AIRCRAFT PERFORMANCE

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

SEMESTER – VI

Course Code	: 21AS3503	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 aircraft performance in steady unaccelerated and accelerated flight.
2. Understand the airplane performance parameters.
3. Acquire the knowledge on aircraft maneuver performance

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teachers 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 Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and roleplaying.
3. Show **Video/animation** films to explain the 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 student's understanding.

Course Content

UNIT – I

08 Hours

THE EQUATIONS OF MOTION STEADY UNACCELERATED FLIGHT

Introduction, Four forces of flight, General equation of motion, Power available and power-required curves. Thrust available and thrust required curves. Conditions for power required and thrust required minimum. Thrust available and maximum velocity, Power available and maximum velocity, Altitude effects on power available and power required; thrust available and thrust required.

UNIT – II

12 Hours

STEADY PERFORMANCE – LEVEL FLIGHT, CLIMB & GLIDE

Performance: Equation of motion for Rate of climb- graphical and analytical approach -Absolute ceiling, Service ceiling, Time to climb – graphical and analytical approach , climb performance graph (hodograph diagram), Gliding flight, Range during glide, minimum rate of sink and shallowest angle of glide.

Fundamental Airplane Performance Parameters The fundamental Parameters: Thrust – to – weight ratio, Wing loading, Drag polar, and lift-to – drag ratio. Minimum velocity. Aerodynamic relations associated with lift-to-drag ratio.	
UNIT – III	08 Hours
RANGE AND ENDURANCE Propeller driven Airplane: Physical consideration, Quantitative formulation, Breguet equation for Range and Endurance, Conditions for maximum range and endurance. Jet Airplane: Physical consideration, Quantitative formulation, Equation for Range and Endurance, Conditions for maximum range and endurance, Effect of head wind tail wind.	
UNIT – IV	08 Hours
AIRCRAFT PERFORMANCE IN ACCELERATED FLIGHT Take-off Performance: Calculation of Ground roll, Calculation of distance while airborne to clear obstacle, Balanced field length Landing Performance and Accelerated Climb: Calculation of approach distance, Calculation of flare distance, Calculation of ground roll, ground effects. Acceleration in climb.	
UNIT – V	07 Hours
MANEUVERER PERFORMANCE Turning performance: Level turn, load factor, Constraints on load factor, Minimum turn radius, Maximum turn rate. Pull-up and Pull-down maneuvers: (Turning rate, turn radius). Limiting case for large load factor. The V-n diagram.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Understand Equations of motion for unaccelerated steady flight.	L2 & L3
2	Develop the equation for the steady performance of level, climb and glide flight	L3&L4
3	Calculate the Range and Endurance of propeller driven and jet driven airplanes	L2 & L3
4	Enumerate aircraft performance like takeoff, and landing of accelerated Flight	L3 & L4
5	Understand the V-n diagram and calculate the Maneuver performance of the accelerated Flight	L2 & L3
6	Understand the different phases of weight estimations required for designing of aircrafts	L3 & 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	3
CO1	2	1	1										3		
CO2	2	2			1								3	2	
CO3	2				2								2	2	
CO4	3	1	1		1					1			2	2	

C05	2	2				1			1			3		1
C06	3	1				1			1			2	2	

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. John D. Anderson, Jr. "Aircraft Performance and Design", McGraw-Hill International Editions, Aerospace Science/ Technology Editions, 1999.
2. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill International Editions, Aerospace Science/ Technology Editions, 2000.

Reference Books:

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.

INTRODUCTION TO SPACE TECHNOLOGY			
SEMESTER – V			
Course Code	: 21AS3504	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		
<u>Course Learning Objectives:</u>			
This course will enable students to:			
1. Analyze the fundamentals of space technology: Students will gain a comprehensive understanding of the basic principles and concepts related to space technology, 2. Interpret: Students will gain an understanding of past and ongoing space exploration missions, including robotic and manned missions to planets, moons, asteroids, and other celestial bodies 3. Identify: Students will be introduced to the various types of space launch systems, such as expendable launch vehicles and reusable launch vehicles. 4. Describe:the diverse applications of space technology, including satellite navigation systems, weather forecasting, Earth observation, and space tourism			
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			08 Hours

SPACE ENVIRONMENT	
Introduction to space technology, Milestones in Global Space Technologies, Atmosphere, Neutral atmosphere, Plasma, Solar Cycle, Solar Radiation, Radiation Belts, Earth's Magnetic field, Space Debris, Electro static charging, meteoroid impact, Effect of environment on Spacecraft, Aerodynamic drag, orbital mechanics.	
UNIT - II	08 Hours
SPACE PROPULSION	
Space Missions, objectives, Types of space travel, Principle of rocket launching, Rocket Propulsion, Staging, Solid propellant, liquid propellant and cryogenic Propulsion, Electric Propulsion, Electro-Thermal Thrusters, sounding rockets, PSLV, GSLV, Launch window, Reusable Launch Vehicle (RLV)	
UNIT - III	06 Hours
SATELLITE & SUBSYSTEMS	
Power Systems, Attitude Determination and Control system, Guidance and Navigation, Avionics, Telemetry, tracking and command, Communication, Structure and Mechanisms, Thermal System	
UNIT - IV	09 Hours
NANOSATELLITE, ROVERS & ASTRONAUTICS	
Types of spacecraft, Payload, design consideration for payloads, nano propulsion, thermal control systems, photovoltaic power generation, Solar array, Batteries, testing of satellites, simulation, concepts related to Astronautics & Space entrepreneurship	
UNIT - V	08 Hours
TESTING OF SPACE COMPONENTS AND SYSTEM	
Types of Tests; Test Facilities and Safeguards; Safety and Environmental Concerns; Monitoring and Control of Toxic Materials and Exhaust Gases; Instrumentation and Data Management; Reliability and Quality Control; Flight Testing. Assembly integration test, comprehensive test & test vacuum chamber and comprehensive test & test vibration facilities	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Outline the fundamental concepts and principles of space technology. They will understand the basic principles of rocketry, satellite design and operation, space exploration, and the various components and systems used in space missions.	L2 & L3

2	Interpret: Students will develop the ability to interpret and analyze data related to space technology.	L2 & L3
3	Describe: Upon completion of the course, students will be able to describe the different types of space missions and their objectives. They will be familiar with the main types of satellites, such as communication satellites, weather satellites, and scientific satellites, and will understand their specific purposes and functions	L2 & L3
4	Identify and Explain: Students will gain the skills to identify and explain the key components and systems involved in space technology. They will be able to identify the major parts of a rocket and explain their functions.	L2 & L3
5	Describe: Students will be able to describe the impact of space technology on various aspects of human life and society. They will understand how space technology is used for communication, weather forecasting, navigation, Earth observation, and scientific research..	L2

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	3							2		3
C02	3	3	2	3	3							2		3
C03	3	3		3	3							1		3
C04	3	3	2	2	3							2		3
C05	3	3			2							1		3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

TEXTBOOKS:

1. Book Title: Space Technology Author: Ignacio Chechile Publication: Springer Cham Year: 2017 Edition: 1 Volume: 1 DOI: <https://doi.org/10.1007/978-3-031-34818-1>
2. Book Title: Introduction to Satellite Communication Author: Bruce R. Elbert Year: 2018 Edition: 2 Volume: 3

REFERENCE BOOKS:

3. "Space Mission Engineering: The New SMAD" by James R. Wertz and Wiley J. Larson, Volume: 4th Edition, 2 volumes, Publication: Microcosm Press
4. "Introduction to Space Dynamics" by William Tyrrell Thomson, Volume: 1st Edition, 2 volume, Publication: Dover Publications
5. "Spacecraft Systems Engineering" by Peter Fortescue, John Stark, and Graham Swinerd, Volume: 4th Edition, Publication: Wiley

E-Resources:

<https://archive.nptel.ac.in/courses/101/106/101106046/>

Activity-Based Learning (Suggested Activities in Class)

1. Group discussions on a mission, satellite building, and propulsions technology
2. Site visit/Video demonstrations on the building/launching of a spacecraft

WIND TUNNEL TESTING

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

Course Code : 21AS3508

Credits : 03

Hours / Week : 03 Hours

Total Hours : 39 Hours

L-T-P-S : 3-0-2-0

COURSE OBJECTIVES:

This course will enable students to:

1. Understand the need for experimental aerodynamics, types of wind tunnels and their application areas
2. Understand the design of wind tunnels, test section & drive system
3. Explain various types of test techniques & types of measurements and uncertainties
4. Acquire knowledge on design on models for wind tunnel testing
5. Carry out simple experiments in the DSU wind tunnel

Teaching-Learning Process (General Instructions)

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

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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 WIND TUNNELS:

(Selected Chapters from Text Books 1 to 4)

Aerodynamics, Properties of Air and Water, Similarity Parameters, Incompressible Flow, Types of Wind Tunnels and their applications

UNIT – II

08 Hours

COMPONENTS OF WIND TUNNEL SYSTEMS

(Text Books 2-3)

Overall Objectives, Power Considerations, Energy Ratio of typical Wind Tunnels, Cooling, Test Section Flow Quality, Drive Systems, Wind Tunnel Construction, Test Section Inserts, Safety

UNIT - III		06 Hours
MEASUREMENT TECHNIQUES AND CALIBRATION OF TEST SECTION (Text Book-3)		
Flow Visualization Techniques, Pressure, Force and Moment measurements, Boundary Layer measurements, External and Internal Balances, Balance requirements and Specifications, Installation in models, Calibration and use of transonic & supersonic wind tunnels, Design of models (Force models, pressure models and spin models) and instrumentation systems		
UNIT - IV		10 Hours
SPECIAL TEST TECHNIQUES AND DATA REDUCTION (Text Book - 3)		
Data Reduction from Wind Tunnel Tests, Scale Effects, Corrections to Wind Tunnel Data, Measurement Uncertainties		
UNIT - V		08 Hours
Experiments in DSU Wind Tunnel		
Design and manufacturing of simple models for testing in DSU low speed wind tunnel, analyses of experimental findings and documentation		

COURSE OUTCOMES:

Upon successful completion of this course, the students will be able to:

1. **Compare** the performance of different types of wind tunnels and their applications
2. **Analyse** the various components of wind tunnels, design and performance aspects, types of test sections
3. **Apply** measurement techniques, typical instruments and methods of testing
4. **Apply** data reduction and evaluate measurement uncertainties
5. **Create** and manufacture of 3-D printed simple models for wind tunnel testing

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

3: Substantial (High)

2: Moderate (Medium)

1: Poor 2(Low)

TEXT BOOKS:

1. Jewel B. BARLOW, William H. RAE Jr., Alan POPE, "Low-Speed Wind Tunnel Testing", John Wiley & Sons, New York, Toronto, 1999, 3rd Edition, ISBN 978-0-471-55774-9

2. Alan Pope and Kenneth L Goin, "High-Speed Wind Tunnel Testing", John Wiley and Sons, New York, 1965

REFERENCE BOOKS:

1. Liepmann, H W and Roshko A, Elements of Gas Dynamics", Dover Publications, 2013. ISBN 9780486316857
2. John D Anderson Jr., "Fundamentals of Aerodynamics", 5th Edition, McGraw Hill Education (India) Pvt. Ltd., 2010

E-Resources:

1. <https://nptel.ac.in/courses/101106040> Prof Job Kurian, IIT Madras

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion, e.g., Sports aerodynamics, Automotive and Industrial aerodynamics

AIR TRANSPORTATION SYSTEM [As per Choice Based Credit System (CBCS) scheme]	
Course Code : 21AS3509	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 Hours
L-T-P-S : 3-0-2-0	
<u>COURSE OBJECTIVES:</u> This course will enable students to: 1. Understand the air transport systems. 2. Acquire the knowledge of aircraft characteristics, airlines and airport. 3. Details the concepts of airspace infrastructure and its requirements for operation and services 4. Understand the different concepts of navigation, Communication and environmental systems. 5. Understand the Managerial concepts and its aspects behind the air transportation system	
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
Environment, transport and mobility. Systematic description and current challenges. Development of aircraft design driver-speed and range. Development of Airport, Airlines, ICAO, Regulatory Framework and Market Aspects.	
UNIT – II	08 Hours
Classification of flight vehicles, cabin design, basics of flight physics- structures, mass and balance. Flight performance and mission. Aircraft manufacturers, development process, production process, supply chain.	
UNIT – III	06 Hours

Airline types, Network management. Flight strategy and aircraft selection, flight operations, MRO. Role of Airport, Regulatory Issues, Airport operation and services. Airport planning - Infrastructure.	
UNIT – IV	10 Hours
Principle of operation- Role of Air Navigation services. Air space structures, Airspace and Airport capacity, Aircraft separation. Flight guidance system. Communication system. Integrated air traffic management and working system. Environmental aspects-emission, noise, and sound.	
UNIT – V	08 Hours
Airline passenger marketing, forecasting methods, pricing and demand. Air cargo-market for air freight. Principles of airline scheduling. Fleet planning	

COURSE OUTCOMES:

Upon successful completion of this course, the students will be able to:

1. Understand the complete insight of Air transportation system.
2. Explore the knowledge about basic aircraft characteristics, cabin design and manufacturers.
3. Illustrate the detailed structure Airlines, Airports and its Infrastructure
4. Understand the different air navigation and environmental systems used for improving the ATS
5. List the Managerial aspects of Airlines

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	2									1	2	
C02	3	2											1	2	
C03	2	3		2									1	2	
C04	3	3		2									1	2	
C05	3	1	1										1	2	
3: Substantial (High)					2: Moderate (Medium)					1: Poor 2(Low)					

Text Books:

- 1) Dieter Shmitt, and Valker Gollnick, Air Transport System, Springer, 2016.
- 2) John G Wensveen, Air Transportation-A Management Prospective, Ashgate Publishing Ltd, 2011.

Reference Books:

- 1) Mike Hirst, The Air Transportation System, Wood head publishing Ltd, England, 2008

MODEL BASED SYSTEMS ENGINEERING

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

Course Code : 21AS3505

Credits : 03

Hours / Week : 03 Hours

Total Hours : 39Hours

L-T-P-S : 3-0-2-0

COURSE OBJECTIVES:

This course will enable students to:

1. Student uses the knowledge and information gained in the course to expand and
2. Improve the application of model-based systems engineering in their field.
3. Student implements model-based systems engineering practices in their field the result in higher levels of value and satisfaction with engineered systems.
4. Student pursues further in-depth education and training in systems 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

08 Hours

WHAT IS LANDING GEAR & FUNCTION, TYPES OF LANDING GEAR, DIFFERENT PARTS OF A MODERN LANDING GEAR, DIFFERENT PARTS OF A MODERN LANDING GEAR SHOCK STRUT

UNIT – II

08 Hours

Steering System, Brakes, Uplock & Downlock, Retraction & Extension, Emergency lowering of Landing Gear

UNIT – III

06 Hours

Introduction to MBSE Process LG Design Process Requirement Management Theory, Requirement Management Lab, Functional Architecture, Mapping Requirements and Functional Components, practice sessions.

UNIT - IV	10 Hours
INTRODUCTION TO MATHEMATICAL MODELING & DESIGN OF A DC MOTOR, LG DETAIL DESIGN PROCESS PRACTICE SESSION, LOGICAL ARCHITECTURE DEFINITION, PHYSICAL CAD INTEGRATION,	
UNIT - V	08 Hours
Mapping Functional and Logical Components, Test Case Validation and Impact Analysis	

COURSE OUTCOMES:

Upon successful completion of this course, the students will be able to:

1. Demonstrate analysis of systems using model-based systems engineering approaches that lead to better and increased performance of systems.
2. Describe the processes, methods, and practices of model-based systems 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	3
C01	3	3											1	2	
C02	3	1											1	2	
C03													1	2	
C04													1	2	
C05													1	2	
3: Substantial (High)					2: Moderate (Medium)					1: Poor 2(Low)					

INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS

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

SEMESTER - V

Course Code	: 21AS3506	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 26 + 26 Hours
L-T-P	: 2-0-2		

Course Learning Objectives:

This course will enable students to:

1. Explain the basic governing equations and understand the properties of CFD.
2. Understand discretization techniques and solving methods for improving accuracy.
3. Inculcate the knowledge required to solve physical problems using simulation software.

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

03 Hours

Introduction:

Advantages and applications of CFD, CFD solution procedure – Pre-process, CFD solver, Post process, testing.

UNIT - II

06 Hours

Governing Equations:

Continuity, momentum and Energy equations, equations for turbulent flows, classification of PDEs, generic form of governing equations for CFD, physical boundary conditions

UNIT - III

04 Hours

Mesh generation:

Overview of mesh generation, Structured and Unstructured mesh,

Guideline on mesh quality and design, Mesh refinement and adaptation, moving mesh.	
UNIT – IV	08 Hours
CFD Techniques: Discretization of governing equations – FDM, FVM, FEM, Numerical solution, Explicit and Implicit schemes, pressure velocity coupling.	
UNIT – V	05 Hours
CFD Solution Analysis: Consistency, stability, convergence, accuracy, efficiency. Guidelines for boundary conditions, turbulence modelling and Validation.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Outline the CFD solution procedure.	L2 & L3
2	Classify PDEs and derive governing equations- continuity, momentum and energy.	L2 & L3
3	Choose 2D grids for a particular fluid flow problem.	L2 & L3
4	Apply finite difference method and finite volume methods for the discretization of the fluid flow problems.	L2 & L3
5	Use of suitable numerical methods for solving the governing equations in the discretized domain by understanding stability and convergence.	L2 & L3
6	Solve fluid flow and heat transfer problems using CFD software	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	3
C01	3				2								2		
C02	3				2								1		
C03	2	2			2							1	1	1	
C04	3	3	2		2									1	
C05	3	2	2		3										
C06	3	2	2	2	3				2	2		2	2	2	
3: Substantial (High)				2: Moderate (Medium)						1: Poor (Low)					

TEXT BOOKS:

1. Jiyuan Tu, Guan-Heng Yeoh, Chaoqun Liu, "Computational Fluid Dynamics A Practical Approach", 3rd Edition, Butterworth-Heinemann, 2018.
2. Atul Sharma, "Introduction to Computational Fluid Dynamics Development, Application and Analysis", ANE Books Pvt. Ltd, Springer Nature Switzerland AG ,2022.

REFERENCE BOOKS:

1. H.K. Versteeg and W. Malalasekera , "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", , Second Edition, Pearson Education Limited, 2007.
2. Anderson J.D. Computational Fluid Dynamics, Mc-Graw Hills (1995)
3. J.C. Tannehill, D.A. Anderson, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis

E-Resources:

1. <https://nptel.ac.in/courses/112105045>

INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS - LAB**Total Contact Hours: 26**

Following simulations to be done using CFD software:

1. Discretization and numerical solution of 1D steady-state heat transfer through the slab.
2. Numerical solution of a potential flow problem.
3. Solution convergence monitoring, flow visualization and post-processing techniques and tools.
4. Introduction to CFD software and setup test case-1 for laminar flow – internal and external.
5. Mesh generation for test case-1 using the inbuilt tool.
6. Grid independence test, results reporting and visualization.
7. CFD study of laminar and turbulent flow around a cylinder. Selection of different turbulent models.
8. CFD study of laminar flow past a backwards-facing step.
9. CFD study of natural convection in a square cavity.
10. CFD study of flow around airfoils.
11. CFD study of compressible flow around cylinders and cones.
12. CFD study of compressible flow around blunt bodies.
13. CFD study of flow behind a rotating cylinder.

FLIGHT PHYSICS LABORATORY
SEMESTER – V

Course Code	:21AS3507	Credits	: 01
Hours / Week	: 02 Hour	Total Hours	: 26 Hours
L-T-P	: 1-0-1		

Course Learning Objectives:

This course will enable students to:

1. Conduct experiments on aerofoil, water flow channel.
2. Conduct experiments on pitot and static tubes.
3. Basic understanding of flow visualization.

COURSE OUTCOMES:

Upon successful completion of this course, the students:

- Understand tubes and there flow performance.
- Determine Performance and force measurement, pressure distribution in ae foil and blunt body.

LIST OF EXPERIMENTS

1. Measurement of pressure distribution over an aero foil
2. Measurement of pressure distribution over a blunt body
3. Flow visualization in water flow channel
4. Force measurement
5. Flow over flat plate
6. Understanding pitot and static tubes

AVIONICS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VI			
Course Code	: 21AS3601	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 39 Hours
L-T-P	: 2-0-2		
<u>Course Learning Objectives:</u> This Course will enable students to: 1. To analyse the integrated requirements of power management, instrumentation, communication, navigation and control system requirements 2. To explain evolution of the avionics systems architectures 3. To describe and interpret the Federated and Integrated Avionics System Architectures involving MAU, LRMs and various digital Data bus networks.			
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			05 Hours
INTRODUCTION: Need for avionics in civil and military aircraft. Power Distribution System: Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilisation - typical application to avionics.			
UNIT – II			05 Hours

Inertial Navigation System: Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing. Electronic Flight Control System: Fly-by-wire system:-basic concept and features. Pitch and Roll rate:-command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common mode of failures and effects analysis.	
UNIT – III	05 Hours
Electronic Flight Instrument Systems: Display -units, presentation, failure, and annunciation. Display of air data. Introduction to Avionics Sub Systems and Electronic Circuits: Typical avionics subsystems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.	
UNIT – IV	05 Hours
Principles of Digital Systems: Digital Computers, Microprocessors, Memories. Flight Deck and Cockpits: Control and display technologies CRT, LED, LCD, EL and plasma panel, Touch screen, Direct voice input (DVI)-Civil cockpit and military cockpit : MFDS, HUD, MFK, and HOTA	
UNIT – V	06 Hours
Avionics Systems Integration: Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic Warfare, and fire control system. Avionics system architecture, Data buses, MIL-STD1553B.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Analyse the requirements and specifications for power distribution elements for typical military and civil aircraft. They will be able to draw, interpret and identify the aircraft electrical circuitry with respect to generation, distribution and utilisation.	3

2	Compare and identify the the navigation system - inertial navigation, electronic flight control and fly-by-wire	3
3	Identify and use installed sensors, communication, flight instrument and displays systems in civil / commercial aircraft	3
4	Select and design the digital avionics architectures and systems for control, communication, displays and electronic warfare in military / civil aircraft.	4
5	Identify and select the appropriate avionics system architecture along with applicable standards	4

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

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. Introduction to Avionics Systems R.P.G. Collinson Springer 3rd edition, 2011
2. Aircraft Systems: Mechanics, Electrical and Avionics Subsystems Integration Ian Moir, Allan Seabridge Wiley 3rd Edition, 2012

Reference Books:

1. Middleton, D.H., Ed., "Avionics Systems, Longman Scientific and Technical", Longman GroupUK Ltd., England, 1989, ISBN-13: 978-0582018815.
2. Spitzer, C.R., "Digital Avionic Systems", McGraw-Hill Inc., US, 2nd edition, 1992, ISBN-13:978-0070603332.
3. Mike Tooley and David Wyatt, Aircraft Communications and Navigation Systems, Butterworth Heinemann, 2007.

E-Resources:

1. Virtual Reality 360 degree cockpit videos - Swiss Air Airbus 320 Flight in Youtube
2. Virtual Aerospace Museums with cockpit views
3. Demonstration in Avionics Laboratory of the key driver software in Flight Simulator

Activity Based Learning (Suggested Activities in Class)

1. Role Play - Primary and Secondary Power Management - Role plays with students playing the characters/avatars around primary and secondary and battery power generation with essential, non-essential and vital consumers.
2. Action based demonstration in class of GPS and Instrumented Landing System

AVIONICS LABORATORY

Total Contact Hours: 26

Following are experiments to be carried out in Avionics Laboratory.

- | | |
|----|--|
| 1 | Studying and verifying the truth table of logic gates |
| 2 | Establishing a direct communication link between Uplink Transmitter and Downlink Receiver using Tone Signal and Voice Signal |
| 3 | Transmitting and receiving PC data, Function Generator Waveforms through Satellite link |
| 4 | Sending tele-command and receiving Intensity of light and Temperature from satellite |
| 5 | Familiarization of Raspberry pi and setting up ETS IoT Trainer Kit |
| 6 | Interfacing LED/Buzzer with Raspberry pi to blink and control RGB LED with a specified time delay and verify the output on the ETS IoT Kit |
| 7 | Associating OLED display and print a message and verify the output on the ETS IoT Kit |
| 8 | Monitoring Temperature & Humidity, Acceleration using sensors using ETS IoT Trainer Kit |
| 9 | Familiarization of digital storage oscilloscope for observing and measuring electronic signals |
| 10 | Analysing wave shapes, measurement of frequency and voltage values at different ac. inputs. |
| 11 | Flight Simulator (Open Ended Experiment) |

ORBITAL MECHANICS

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

SEMESTER – VI

Course Code	: 21AS3602	Credits	: 04
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-S	: 3-0-2-0		

Course Learning Objectives:

This course will enable students to:

1. Understand the basic concepts of space mechanics and the general N- body.
2. Study satellite injection and satellite orbit perturbations.
3. Acquire the knowledge of interplanetary and ballistic missile trajectories

Teaching-Learning Process (General Instructions)

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

2. **Lecture method** means it includes not only traditional lecture method but different *type of teaching methods* may be adopted to develop the course outcomes.
3. **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and roleplaying.
4. Show **Video/animation** films to explain the functioning of various concepts.
5. Encourage **Collaborative** (Group Learning) Learning in the class.
6. To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
7. 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.
8. Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.

Course Content

UNIT – I

10 Hours

Basic knowledge of Space: Overview of major contents of universe, Black body radiation, specific intensity, flux density, luminosity, Basics of radiative transfer (Emission/absorption coefficients, source functions) formation of the solar system, stars, and planets physical processes in the solar system; dynamics of the solar system; physics of planetary atmospheres; individual planets; comets, asteroids, and other constituents of the solar system; extra-solar planets.

System modelling using Block diagrams and Signal Flow Graphs, Masons gain formula.

UNIT – II

08 Hours

Satellite Injection and Satellite Perturbations: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach. Ballistic Missile Trajectories: Introduction to ballistic missile trajectories, boost phase, the ballistic phase, trajectory geometry, optimal flights, time of flight, re-entry phase, the position of impact point, influence coefficients.		
UNIT - III		08 Hours
Interplanetary Trajectories: Two-dimensional interplanetary trajectories, fast interplanetary trajectories, three dimensional interplanetary trajectories, launch of interplanetary spacecraft, trajectory estimation about the target planet, concept of sphere of influence, Lambert's theorem.		
UNIT - IV		07 Hours
Satellite Injection and Satellite Perturbations: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach. Ballistic Missile Trajectories: Introduction to ballistic missile trajectories, boost phase, the ballistic phase, trajectory geometry, optimal flights, time of flight, re-entry phase, the position of impact point, influence coefficients.		
UNIT - V		06 Hours
Launch Vehicle Dynamics: Tsiolkovsky's rocket equation, range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging. Earth launch trajectories – vertical segment, the gravity turn, constant pitch trajectory, orbital injection. Actual launch vehicle trajectories, types. Reusable launch vehicles, future launchers, launch assist technologies. Rocket Thrust Vector Control – Methods of Thrusts Vector Control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; stage separation dynamics, separation techniques..		
Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Apply the basic concepts of space mechanics and the general N-body.	L3&L4
2	Explain satellite injection and satellite orbit perturbations.	L3 & L4
3	Distinguish between interplanetary and ballistic missile trajectories	L3 & 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	3	
CO1	3	2	1		1							1	1			
CO2	3	2			2								1	1		
CO3	3	2	1		1				1	1			1	1		

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. Cornelisse, J.W., Rocket Propulsion and Space Dynamics, W.H. Freeman & co,1984.
2. Thomson, Introduction to Space Dynamics, Dover Publications, Revised edition,2012

REFERENCE:

1. Van de Kamp, P., "Elements of Astromechanics", Pitman, 1979
2. Willian E. Wiesel, Space Flight Dynamics, Create Space Independent Publishing Platform, 3rd Edition ,2010,ISBN-13: 978-1452879598
3. George P. Sutton and Oscar Biblarz, Rocket Propulsion Elements, Wiley India Pvt Ltd, 7th edition, 2010, ISBN-13: 978-8126525775.

CONTROL SYSTEMS

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

SEMESTER – VI

Course Code	: 21AS3603	Credits	: 04
Hours / Week	: 03 Hours	Total Hours	: 39 +26 Hours
L-T-P-S	: 3-0-2-0		

Course Learning Objectives:

This course will enable students to:

4. Derive transfer function and state space models from a description of a physical system.
5. Analyse time and frequency domain response characteristics from plots, determine stability and predict responses for modified plots.
6. Analyse industrial controllers.
7. Analyse different compensators.
8. Apply state space techniques to determine the controllability and observability of feedback control systems
9. Use software tools for the analysis and design of control systems.

Teaching-Learning Process (General Instructions)

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

10. **Lecture method** means it includes not only traditional lecture method but different *type of teaching methods* may be adopted to develop the course outcomes.
11. **Interactive Teaching: Adopt Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and roleplaying.
12. Show **Video/animation** films to explain the functioning of various concepts.
13. Encourage **Collaborative** (Group Learning) Learning in the class.
14. To make **Critical thinking**, ask at least three Higher-order Thinking questions in the class.
15. 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.
16. Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
17. Discuss how every **concept can be applied to the real world** - and when that's possible, it helps improve the student's understanding.

Course Content

UNIT – I

10 Hours

Concepts of automatic control, Open loop and closed loop systems, Concepts of feedback, and requirements of an ideal control system. Mathematical Models: Transfer function models – Mechanical, electrical, thermal and fluid systems. Introduction to State space representation. System modelling using Block diagrams and Signal Flow Graphs, Mason's gain formula.

UNIT – II

08 Hours

Time Response: System response, standard test signals. Response of I order system to step, ramp and impulse inputs. General II order system, response to step and impulse inputs. Transient response specifications. Poles and Zeros, effect of additional poles and zeros on the system response. System Stability: Bounded Input and Bounded Output stability, Stability analysis using Routh's stability criterion.	
UNIT – III	08 Hours
Root locus plots: Guidelines for determining root locus, stability analysis using root locus plots. Frequency response using Bode plots and Nyquist plots. Stability analysis using Bode and Nyquist plots.	
UNIT – IV	07 Hours
Basic equations of control – stability, tracking, regulation, sensitivity. Steady-state errors and their control. Controllers: Proportional, Integral, Derivative, PI and PID controllers, feedforward control. System compensation: Lead, Lag, Lead Lag compensation. Compensator design using Root locus and Bode plots.	
UNIT – V	06 Hours
State Space Design: Advantages of state-space, system description in state-space, analysis of state equations. Controllability and Observability.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Apply physical laws to derive transfer function and state space models of mechanical, electrical, thermal and fluid systems.	L3&L4
2	Analyze the time response of I and II order systems for step, ramp and impulse inputs and calculate the transient response specifications.	L3 & L4
3	Compute the stability and relative stability of the control system in the time and frequency domain using Routh stability, root locus, Bode and Nyquist plots.	L3 & L4
4	Design controllers and compensators based on stability and performance requirements.	L3 & L4
5	Analyze the state equations and calculate the controllability and observability of feedback control systems.	L2 & L3
6	Use software tools like MATLAB to do the calculations required for (1) to (5) above, and use graphical documentation for these analyses.	L3 & 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	3
CO1	3	3	1		1							1	3		
CO2	3	3			2								2	1	
CO3	3	3	1		2				1	1			3	1	
CO4	3	3	1	1	2				1	1		1	2	2	1

C05	3	2										2		
C06	3	1			3				3	2		2	3	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

18. Gene F. Franklin, J. David Powell, Abbas Emami-Naeini, "Feedback Control of Dynamic Systems", 8th Ed., Pearson, 2022.
19. Norman S. Nise, "Control Systems Engineering", Wiley India, 2018

REFERENCE BOOKS:

20. Katsuhiko Ogata, Modern Control Engineering, 5th Ed., Pearson Education, 2015
21. M.Gopal, Control Systems Principles and Design, TMH, 4th edition, 2012
22. Rao V. Dukkupati, "Analysis and Design of Control Systems using MATLAB", 2nd Edition, New Age Science Ltd, 2009.
23. Farid Golnaraghi and Benjamin C. Kuo, "Automatic Control Systems", 9th edition, Wiley, 2014

E-Resources:

2. <https://nptel.ac.in/courses/107106081>
3. <https://archive.nptel.ac.in/courses/108/106/108106098/>
4. <https://ocw.mit.edu/courses/2-04a-systems-and-controls-spring-2013/pages/lecture-notes-labs/>

Activity-Based Learning (Suggested Activities in Class)

24. Design and analysis of control systems using software tools like MATLAB.,
25. Demonstration of the solution to a problem through programming.

CONTROL SYSTEMS - LAB

Total Contact Hours: 26

Following simulations are to be done using software tools like MATLAB

1. Familiarisation of MATLAB environment, entering commands, arithmetic operations
2. Programming with MATLAB – script files, if statement, for loops, matrix operations.
3. Control system models in transfer function and state space form, poles and zeros of a function.
4. Analysis of response of II order system for step, ramp and impulse inputs, effect of additional poles and zeros on the system response.
5. Stability analysis using root locus plots.
6. Stability analysis using Bode and Nyquist plots.
7. Familiarisation with the SIMULINK environment.
8. Design of controllers - PI and PD.
9. Design and analysis of PID controller.
10. Design of satellite's attitude control.
11. Lateral and Longitudinal control of Boeing 747.
12. Control of Quadrotor drone.

AIRCRAFT STABILITY & CONTROL			
SEMESTER – VI			
Course Code	: 21AS3604	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		
<u>Course Learning Objectives:</u>			
This course will enable students to:			
1. Understand the basics of aircraft stability and control. 2. Understand the static longitudinal and static directional stability. 3. Acquire the knowledge on dynamic lateral and directional stability.			
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			08 Hours
Historical perspective, Aerodynamic Nomenclature, Equilibrium conditions, Definition of static stability, Definition of longitudinal static stability, stability criteria, Contribution of airframe components: Wing contribution, Tail contribution, Fuselage contribution, Power effects- e Introduction, Trim condition. Static margin, Stick fixed neutral points.			

Longitudinal control, Power by wire system and EHA	
UNIT – II	08 Hours
Elevator power, Elevator angle versus equilibrium lift coefficient, Elevator required for landing, Restriction on forward C.G. range. Hinge moment parameters, Control surface floating characteristics and aerodynamic balance, Estimation of hinge moment parameters, The trim tabs, Stick-free Neutral point, Stick force gradient in un accelerated flight, Restriction on aft C.G.	
UNIT – III	06 Hours
Introduction, Definition of directional stability, Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin, one engine inoperative condition, Weather cocking effect.	
UNIT – IV	09 Hours
Introduction, definition of roll stability, estimation of dihedral effect. Effect of wing sweep, flaps, and power, Lateral control, Estimation of lateral control power, Aileron control forces, balancing the aileron. Coupling between rolling and yawing moments. Adverse yaw effects, Aileron reversal. Definition of Dynamic longitudinal stability.	
UNIT – V	08 Hours
Types of modes of motion: long or phugoid motion, short period motion, Airplane Equations of longitudinal motion. Aerodynamic force and moment representation, Routh's criteria, Factors affecting period and damping of oscillations. Effect of wind shear, flying qualities in pitch, Cooper-Harper Scale. Sideslip excursion. Dutch roll and Spiral instability. Auto- rotation and spin.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Understand the contribution of various airframe components on longitudinal static stability in stick fixed condition and responses required from control surfaces to overcome sudden aerodynamic unbalancing.	L2 & L3
2	Evaluate stick force required at stick free condition and understand the basic concepts of static directional stability.	L2 & L3
3	Predict aileron control forces and flying modes such as Dutch	L2 & L3

	roll, spiral roll, phugoid, long period oscillation with the help of Routh's criterion, for a given stability equation.	
4	Estimate the dynamic derivatives for forward speed, pitching velocity, time rate of change of angle of attack, rolling rate and yawing rate.	L2 & L3
5	Develop various inter-coupling effects with the motion of aircraft and Examine the response of an aircraft	L2

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	3							2		
C02	3	2	1	3	2							2		
C03	3	2		3	3							1		
C04	3	2	1	2	1							2		
C05	3	3			2							1		
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

Text Books:

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.
2. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2007.

Reference Books:

1. Bandu N. Pamadi, 'Performance, Stability, Dynamics and Control of Airplanes', AIAA 2nd Edition Series, 2004.
2. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill, International Editions, Aerospace Science Technology Editions, 2000.

INTRODUCTION TO FINITE ELEMENTAL ANALYSIS			
SEMESTER – VI			
Course Code	: 21AS3605	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		
Course Learning Objectives:			
This course will enable students to:			
1. Use finite element methods to analyze engineering problems.			
2. Understand and perform finite element analysis of 1D and 2D structures.			
3. Perform finite element based steady-state analysis for beam bending and heat transfer 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.			
17. 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.			
18. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.			
19. Show Video/animation films to explain functioning of various concepts.			
20. Encourage Collaborative (Group Learning) Learning in the class.			
21. To make Critical thinking , ask at least three Higher order Thinking questions in the class.			
22. 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.			
23. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
24. 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: Equilibrium equations in elasticity subjected to body force, traction forces, and stress- strain relations for plane stress and plane strains. General description of finite element method, application and limitations, types of elements based on geometry. Node numbering, half band width Longitudinal control, Power by wire system and EHA			
UNIT – II			08 Hours
Basic Methods in FEM Principle of virtual work, principle of minimum potential energy, Raleigh's Ritz method. Direct approach or stiffness matrix formulation of bar element and Galerkin's method			

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

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

- 1) T.R. Chandrupatla and A.D Belegundu , Finite Elements in Engineering, 3rd Ed PHI.
- 2) S.S. Rao, Finite Element Method in Engineering, 4th Edition, Elsevier, 2006.

Reference Books:

- 1) R.D. Cook D.S Maltus, M.E Plesha and R.J.Witt, Concepts and applications of Finite Element Analysis, Wiley 4th Ed, 2009
- 2) J.N.Reddy, Finite Element Method, McGraw -Hill International Edition

LIST OF EXPERIMENTS

1. Geometry clean up and defeaturing
2. 2D meshing and preprocessing for beam bending
3. 3D meshing and preprocessing for propeller shaft
4. Solution Parameter Selection and Input Deck for asymmetric beam bending
5. Deflections and stresses of connecting rod assembly
6. Factor of safety and joint integrity of bolted joint assembly
7. Thermal clearance estimation in aeroengine under steady state thermal conditions
8. Implementation of Temperature dependent properties
9. Convergence studies based on solution parameters
10. Open Experiment – Any one Non linear capability exploration – material, contact or geometri

Artificial Intelligence and Machine learning			
Course Code	: 21AS3607	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		
<u>Course Learning Objectives:</u> This course will enable students to: The course aims to provide a foundation in artificial intelligence techniques for planning, with an overview of the wide spectrum of different problems and approaches, including their underlying theory 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. 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			08 Hours
Introduction to Data Science and AI & ML, Data Science, AI & ML, Essential Concepts in AI and ML Data Understanding, Representation and Visualisation			
UNIT - II			08 Hours
Machine Learning: Linear Methods, Linear Regression, Multiple Linear Regression, Non-Linear Regression, Clustering, Forecasting models, Perceptron and Neural Network, Decision Trees, Support Vector Machines			
UNIT - III			06 Hours

Probabilistic Models, Dynamic programming and Reinforcement Programming, Evolutionary Algorithms, Time Series Models, Deep Learning, Emerging Trends in ML, Unsupervised Learning	
UNIT - IV	09 Hours
Foundations for AI, AI Basics, AI Classification, Supervised Learning, Feature Engineering Regression, Model Selection, Model Performance, Ranking	
UNIT - V	08 Hours
Introduction to ML with R and using Python, Python and R for Artificial Intelligence, Machine Learning, and Data Science, AI/ML in aerospace industry	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understanding fundamental of the history of artificial intelligence (AI) and its foundations.	2
2	Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning	2
3	Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.	3

[illegible]

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books

1. Machine Learning and Artificial Intelligence, Ameet V Joshi, Springer, Microsoft(USA),Redmond, ISBN 978-3-030-26621-9
2. Artificial Intelligence and Machine Learning fundamentals, Zolt Nagy,Pact Publishing, UK, ISBN 978-1-78980-165-1

Reference Books

1. Artificial Intelligence and Machine Learning, Vinod Chandra SS , PHI, ISBN 978-81-203-4934-6
2. Basics of Artificial Intelligence and Machine Learning, Dheeraj Mehrotra,Notion Press, eISBN 978-1-64587-283-2

UNMANNED AERIAL VEHICLE & E-MOBILITY			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Course Code	: 21AS3608	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 39 Hours
L-T-P	: 2-0-2		
<u>Course Learning Objectives:</u> This course will enable students to:			
1. To understand roles and responsibilities for UAVs. 2. To identify and define aircraft systems and navigation 3. To understand the basics of electric vehicles, their architecture and modeling.			
1. Teaching-Learning Process (General Instructions) 2. These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 3. 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. 4. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 5. Show Video/animation films to explain functioning of various concepts. 6. Encourage Collaborative (Group Learning) Learning in the class. 7. To make Critical thinking, ask at least three Higher order Thinking questions in the class. 8. 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. 9. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. 10. 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
Introduction to Unmanned Aircraft Systems (UAS).The Beginning The Need for Effective Control The First Modern Unmanned Aircraft; The Target Drone Some Applications of UAS, The Systemic Basis of UAS System Composition Basic Technology Control Methods. Classification of UAS Long-endurance, Long-range Role Aircraft Medium-range, Tactical Aircraft Close- range/Battlefield Aircraft; MUAV Types MAV and NAV Types, UCAV Novel Hybrid Aircraft, Configurations Research UAV			
UNIT – II			10 Hours
Introduction to Design and Selection of the System Conceptual Phase Preliminary Design Detail Design Selection of the System Aerodynamics and Airframe			

Configurations Lift-induced Drag Parasitic Drag Rotary-wing Aerodynamics Response to Air Turbulence Airframe Configurations Transportation: Micro-UAV VTOL Close-range Systems HTOL Close-range Systems Medium- range Systems MALE and HALE Systems	
UNIT – III	10 Hours
THE DEVELOPMENT OF UAV SYSTEMS Introduction to System Development and Certification System Development Certification Establishing Reliability System Ground Testing UAV Component Testing UAV Sub-assembly and Sub-system Testing Complete UAV Control Station Testing Catapult Launch System Tests Documentation System In-flight Testing Test Sites Preparation for In-flight Testing In-flight Testing System Certification	
UNIT – IV	08 Hours
Electro mobility and the Environment A Brief History of the Electric Powertrain, Energy Sources for Propulsion and Emissions, The Advent of Regulations, Drive Cycles, BEV Fuel Consumption, Range, and mpge, Carbon Emissions for Conventional and Electric Powertrains, An Overview of Conventional, Battery, Hybrid, and Fuel Cell Electric Systems, A Comparison of Automotive and Other Transportation Technologies. Vehicle Dynamics: Vehicle Load Forces, Vehicle Acceleration, Simple Drive Cycle for Vehicle Comparisons	
UNIT – V	08 Hours
Battery Management & EV Simulation Batteries Types and Battery Pack, Lifetime and Sizing Considerations, Basic Requirements for Charging System, Charging Standards and Technologies, BMS Definition, Li-Ion Cells, Li-Ion BMSs, Li-Ion Batteries, BMS Functions: Measurement: Voltage, Temperature, Current. EV Simulations: system level simulation, EV simulator, simulator modules, performance evaluation, system optimization.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Describe different phases of design of UAVs.	2
2	Describe the basic principles of UAS operation requirements and develop concept operation	2
3	Describe various E-Vehicle management systems and its simulations.	3

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	2	1	3	3							2		1	2	
CO 2	2	1	2	2							1		1	1	
CO 3	2	1	1	1							1		1	1	
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)							

Text books:

1. Reg Austin, Unmanned Aircraft systems UAVs Design, Development and Deployment, A John Wiley & Sons,Ltd.,2010.
2. Douglas M.Marshall et al., Introduction to unmanned Aircraft systems, second edition Taylor & Francis, 2016.
3. Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, G. Abas Goodarzi, 1st Edition, 2018, Wiley, ISBN 9781119063667.

Reference Books:

1. Jay Gundlach, Civil and commercial Unmanned Aircraft Systems, AIAA Education Services, 2016
2. Battery Management system for large Lithium Battery Packs, Davide Andrea, 1st Edition, 2010, ARTECH HOUSE, ISBN-13 978-1-60807-104-3
3. Hybrid Vehicles from Components to System, F. BADIN, Ed, 1st Edition, 2013, Editions Technip, Paris, ISBN 978-2-7108-0994-4.
4. Modern Electric Vehicle Technology C.C. Chan and K.T. Chau, 1st Edition, 2001, Oxford university press, ISBN 0 19 8504160.

**INTRODUCTION TO SPACE
TECHNOLOGIES**

SEMESTER – VI

Course Code	: 210E0048	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		

Course Learning Objectives:

This course will enable students to:

5. **Analyze** the fundamentals of space technology: Students will gain a comprehensive understanding of the basic principles and concepts related to space technology,
6. **Interpret:** Students will gain an understanding of past and ongoing space exploration missions, including robotic and manned missions to planets, moons, asteroids, and other celestial bodies
7. **Identify:** Students will be introduced to the various types of **space launch systems**, such as expendable launch vehicles and reusable launch vehicles.
8. **Describe:**the diverse applications of space technology, including satellite navigation systems, weather forecasting, Earth observation, and space tourism

Teaching-Learning Process (General Instructions)

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

25. **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
26. **Interactive Teaching:** Adopt the **Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
27. Show **Video/animation** films to explain functioning of various concepts.
28. Encourage **Collaborative** (Group Learning) Learning in the class.
29. To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
30. 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.
31. Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.
32. 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
SPACE ENVIRONMENT Introduction to space technology, Milestones in Global Space Technologies, Atmosphere, Neutral atmosphere, Plasma, Solar Cycle, Solar Radiation, Radiation Belts, Earth's Magnetic field, Space Debris, Electro static charging, meteoroid impact, Effect of environment on Spacecraft, Aerodynamic drag, orbital mechanics.	
UNIT – II	08 Hours
SPACE PROPULSION Space Missions, objectives, Types of space travel, Principle of rocket launching, Rocket Propulsion, Staging, Solid propellant, liquid propellant and cryogenic Propulsion, Electric Propulsion, Electro-Thermal Thrusters, sounding rockets, PSLV, GSLV, Launch window, Reusable Launch Vehicle (RLV)	
UNIT – III	06 Hours
SATELLITE & SUBSYSTEMS Power Systems, Attitude Determination and Control system, Guidance and Navigation, Avionics, Telemetry, tracking and command, Communication, Structure and Mechanisms, Thermal System	
UNIT – IV	09 Hours
NANOSATELLITE, ROVERS & ASTRONAUTICS Types of spacecraft, Payload, design consideration for payloads, nano propulsion, thermal control systems, photovoltaic power generation, Solar array, Batteries, testing of satellites, simulation, concepts related to Astronautics & Space entrepreneurship	
UNIT – V	08 Hours
TESTING OF SPACE COMPONENTS AND SYSTEM Types of Tests; Test Facilities and Safeguards; Safety and Environmental Concerns; Monitoring and Control of Toxic Materials and Exhaust Gases; Instrumentation and Data Management; Reliability and Quality Control; Flight Testing. Assembly integration test, comprehensive test & test vacuum chamber and comprehensive test & test vibration facilities	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Outline the fundamental concepts and principles of space technology. They will understand the basic principles of rocketry, satellite design and operation, space exploration, and the various components and systems used in space missions.	L2 & L3

2	Interpret: Students will develop the ability to interpret and analyze data related to space technology.	L2 & L3
3	Describe: Upon completion of the course, students will be able to describe the different types of space missions and their objectives. They will be familiar with the main types of satellites, such as communication satellites, weather satellites, and scientific satellites, and will understand their specific purposes and functions	L2 & L3
4	Identify and Explain: Students will gain the skills to identify and explain the key components and systems involved in space technology. They will be able to identify the major parts of a rocket and explain their functions.	L2 & L3
5	Describe: Students will be able to describe the impact of space technology on various aspects of human life and society. They will understand how space technology is used for communication, weather forecasting, navigation, Earth observation, and scientific research..	L2

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	3							2		3
C02	3	3	2	3	3							2		3
C03	3	3		3	3							1		3
C04	3	3	2	2	3							2		3
C05	3	3			2							1		3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

TEXTBOOKS:

- Book Title: Space Technology Author: Ignacio Chechile Publication: Springer Cham Year: 2017 Edition: 1 Volume: 1 DOI: <https://doi.org/10.1007/978-3-031-34818-1>
- Book Title: Introduction to Satellite Communication Author: Bruce R. Elbert Year: 2018 Edition: 2 Volume: 3

REFERENCE BOOKS:

- "Space Mission Engineering: The New SMAD" by James R. Wertz and Wiley J. Larson, Volume: 4th Edition, 2 volumes, Publication: Microcosm Press
- "Introduction to Space Dynamics" by William Tyrrell Thomson, Volume: 1st Edition, 2 volume, Publication: Dover Publications
- "Spacecraft Systems Engineering" by Peter Fortescue, John Stark, and Graham Swinerd, Volume: 4th Edition, Publication: Wiley

E-Resources:

<https://archive.nptel.ac.in/courses/101/106/101106046/>

Activity-Based Learning (Suggested Activities in Class)

3. Group discussions on a mission, satellite building, and propulsions technology
4. Site visit/Video demonstrations on the building/launching of a spacecraft

SATELLITE TECHNOLOGIES

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

SEMESTER – VI

Course Code	: 21OE0050	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		

Course Learning Objectives:

This course will enable students to get exposed to:

1. Different types of Satellites & Payloads and their applications, Mission Planning, Selection of suitable payloads and sensors for various missions & applications
2. Mainframe Subsystems and Payloads, Mechanical, Propulsion, Thermal and Electrical Subsystems of satellite such as Power, Telemetry, Telecommand, Control Electronics, Sensors, Communication, Data Handling System & Solid State Recorder
3. Spacecraft configuration, spacecraft architecture, accommodation studies and functions of subsystems
4. Spacecraft Systems Engineering, Assembly, Integration & Testing (AIT) towards satellite realisation, subsystems integration, system level testing and facilities for testing
5. Navigation, Guidance and Control (NGC), Mission Software, Reliability & Quality Assurance (R&QA), Safety Aspects
6. Practical Experiments using CANSAT (Satellite in a Can), Class Room Model Cubesat - Mechanical, Thermal and Electrical Aspects

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 <i>different ways to solve</i> the same problem and encourage the students to come up with their own creative ways to solve them. 8. Discuss how every <i>concept can be applied to the real world</i> - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours
Types of Satellites & Payloads, Cubesats Overview of Space Environment, Classification of satellites, Types of Orbits, Types of Payloads & Applications, Cubesat Configuration, Payloads for Cubesats, Spacecraft System Engineering - Concepts, Overview of Launch and On-Orbit Operations, Life-Cycle of Satellites, Space Polices & Laws.	
UNIT – II	05 Hours
Spacecraft Bus and Payload Systems: Overview, Model philosophy, Spacecraft configuration, Bus and payload systems requirements, Mechanical and Electrical requirements, Thermal requirements, Accommodation Studies and optimisation, Layouts and ILDs (Inserts Layout Drawings) generation	
UNIT – III	06 Hours
Spacecraft Mainframe Subsystems Mainframe Subsystems-Mechanical: Structure, Propulsion, Thermal and Deployment Mechanisms;Electrical: Power, Telemetry, Telecommand, Control Electronics, Sensors, Communication, Data Handling System & Solid State Recorder	
UNIT – IV	06 Hours
System View of Spacecraft, Space systems architecture: ground, launch and space segments, Subsystems integration and testing, Systems Level testing, Facilities for Spacecraft Testing, Spacecraft realisation, Pre-launch Operations at launch Base	
UNIT – V	05 Hours
Navigation, Guidance and Control (NGC) software, Mission Software, Overview of Reliability & Quality Assurance (R&QA), Reliability in Parts, Materials and Processes, Product Assurance in Manufacturing and AIT, Safety Aspects	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Configure any type of satellites and payload selection to meet the user requirements	2
2	Use Spacecraft Systems Engineering Concepts for Assembly, Integration and Testing (AIT), Systems Level testing, Spacecraft Realisation, Pre- launch Operations at launch Base	3
3	Spacecraft software, R&QA and Spacecraft Safety Aspects	3
4	Design, Development and Deployment of Student satellite	3

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

Text Books

- Spacecraft Systems Engineering**, 4th Edition, Peter Fortescue (Editor), Graham Swinerd (Editor), John Stark (Editor), Wiley Publication, ISBN: 978-0-470-75012-4 September 2011, 728 pages
- Quintessence of Nano-satellite Technology**, Planet Aerospace India, Notion Press.com, 2020, INDIA

References

- Low Earth Orbit Satellite Design**, Authors: Steve Fujikawa, Nicholas Galassi, Alex Chuchra, George Sebestyen, Space Technology Library ISBN 978-3-319-68314-0 ISBN 978-3-319-68315-7 (eBook)

<https://doi.org/10.1007/978-3-319-68315-7> Library of Congress Control Number: 2017955031 © Springer International Publishing AG, 6 February 2018, 320 pages

2. Fundamentals of Space Systems, (Johns Hopkins University Applied Physics Laboratories Series in Science and Engineering) 2nd Edition, Vincent L. Pisacane (Editor), Robert C. Moore (Editor), ISBN 0-19- 507497-1, Oxford University Press Inc. 1994, 788 pages

3. CubeSat Handbook: From Mission Design to Operations, Authors: Chantal Cappelletti, Simone Battistini, Benjamin Malphrus, ISBN-978-0-12-817884-3, Publisher: Elsevier, Sept. 2020, 500 pages

LIST OF EXPERIMENTS:

1. Demonstration of Relation between Frequency and period
2. Frequency measurements through oscillation method
3. Damping measurements through decay method
4. CG measurements by suspension method
5. CG measurement by reaction force
6. CG measurement by knife edge
7. CG measurement by bending method
8. Stress measurements
9. MI measurements by torsional method
10. Importance of Pre-loading and techniques
11. Aerospace Materials Selection and Parameters Comparison
12. Preload adjustment for satellite handling
13. Simulation of Thermal, structural analysis for 4 different subsystems
14. Measurement of input and output parameters of power supply module of satellite
15. Functioning of OBC module of satellite
16. Functioning of Communication system
17. Functioning of Available payload system
18. Overall functioning and noting of various parameters of satellite (Cubesat)
19. Commanding satellite (Class Room Model) remotely for different functions like antenna
20. Deployment Mechanism, Payload subsystem etc.
21. Ground station operations
22. Receiving signals from satellite(s)
23. Analysis of received signal

DAYANANDA SAGAR UNIVERSITY
SHAVIGE MALLESHWARA HILLS, KUMARASWAMY LAYOUT
BENGALURU-560 111, KARNATAKA.

SCHOOL OF ENGINEERING



SCHEME & SYLLABUS
FOR
BACHELOR OF TECHNOLOGY (B.Tech.) – 2020

AEROSPACE ENGINEERING

(ASE)

7TH & 8TH SEMESTERS

(WITH EFFECT FROM 2020-21)

SCHEME - B.TECH 2020-21 ONWARDS
VII SEM - AEROSPACE ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	101	20AS4701	INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS	CR	02	--	02	--	03	*	***
2	101	20AS47XX	PROFESSIONAL ELECTIVE COURSE – III	CR	03	--	--	--	03	*	***
3	101	20AS47XX	PROFESSIONAL ELECTIVE COURSE –IV	CR	03	--	--	--	03	*	***
4	101	200EXXX	OPEN ELECTIVE – III	CR	03	--	--	--	03	*	***
5	101	20AS4702	AVIATION LAW (New course introduced)	CR	02	--	--	--	02	*	***
6	101	20AS4703	MAJOR PROJECT PHASE I	CR	00	--	--	06	03	*	***
7	101	20AS4704	SATELLITE TECHNOLOGIES	CR	02	--	02	--	03	*	***
8	101	20AS4705	SKILL ENHANCE COURSE (TECHNICAL REPORT WRITING) (New course introduced)	CR	--	--	-	02	01	*	***
					15	--	04	08	21		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits

PROGRAM ELECTIVE – III

SL. NO	COURSE CODE	COURSE NAME
1	20AS4706	OPERATION MANAGEMENT FOR AEROSPACE (New course introduced)
2	20AS4707	UNMANNED AERIAL VEHICLE & E MOBILITY

PROGRAM ELECTIVE – IV

SL. NO	COURSE CODE	COURSE NAME
1	20AS4708	AIRWORTHINESS & TECHNICAL PUBLICATION (New course introduced)
2	20AS4709	NPTEL (RESEARCH METHODOLOGY)

Open Elective - III

SL. NO	COURSE CODE	COURSE NAME
1	20OE0036	Operations Management for Aerospace

SCHEME - B.TECH 2020-21 ONWARDS

VIII SEM - AEROSPACE ENGINEERING

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					PREREQUISITE	
					L	T	P	S/P	C	SEM	COURSE CODE
1	101	20AS48XX	PROFESSIONAL ELECTIVE COURSE – V	CR	03	--	--	--	03	*	***
2	101	20AS4801	PROJECT PHASE II	CR	--	--	--	22	11	*	***
					03	--	--	22	14		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,

PROGRAM ELECTIVE – V

SL. NO	COURSE CODE	COURSE NAME
1	20AS4802	HELICOPTER DYNAMICS
2	20AS4803	AIRCRAFT MAINTENANCE, OVERHAUL AND REPAIR
3	20AS4804	NPTEL COURSE

INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code : 20AS4701	Credits : 03
Hours / Week : 04 Hours	Total Hours : 39 Hours
L-T-P : 2-0-2	
<u>Course Learning Objectives:</u> This course will enable students to: 1. Explain the basic governing equations and understand the properties of CFD. 2. Understand discretization techniques and solving methods for improving accuracy. 3. Inculcate the knowledge required to solve physical problems using simulation software.	
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	03 Hours
Introduction: Advantages and applications of CFD, CFD solution procedure – Pre-process, CFD solver, Post process, testing.	
UNIT – II	06 Hours
Governing Equations: Continuity, momentum and Energy equations, equations for turbulent flows, classification of PDEs, generic form of governing equations for CFD, physical boundary conditions	

UNIT - III	04 Hours
Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation, moving mesh.	
UNIT - IV	08 Hours
CFD Techniques: Discretization of governing equations – FDM, FVM, FEM, Numerical solution, Explicit and Implicit schemes, pressure velocity coupling.	
UNIT - V	05 Hours
CFD Solution Analysis: Consistency, stability, convergence, accuracy, efficiency. Guidelines for boundary conditions, turbulence modelling and Validation.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Explain the CFD solution process.	L2
2	Classify PDEs and derive governing equations- continuity, momentum and energy.	L2
3	Choose 2D grids specific to a particular fluid flow problem.	L2&L3
4	Apply finite difference method and finite volume methods for the discretization of the fluid flow problems.	L2 & L3
5	Use of suitable numerical methods for solving the governing equations in the discretized domain by understanding stability and convergence.	L2 & L3
6	Solve fluid flow and heat transfer problems using CFD software	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	3
CO1	3				2								2		
CO2	3				2								1		
CO3	2	2			2							1	1	1	
CO4	3	3	2		2									1	
CO5	3	2	2		3										
CO6	3	2	2	2	3				2	2		2	2	2	
3: Substantial (High)				2: Moderate (Medium)						1: Poor (Low)					

TEXT BOOKS:

1. Jiyuan Tu, Guan-Heng Yeoh, Chaoqun Liu, "Computational Fluid Dynamics A Practical Approach", 3rd Edition, Butterworth-Heinemann, 2018.
2. Atul Sharma, "Introduction to Computational Fluid Dynamics Development, Application and Analysis", ANE Books Pvt. Ltd, Springer Nature Switzerland AG ,2022.

REFERENCE BOOKS:

1. H.K. Versteeg and W. Malalasekera , "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", , Second Edition, Pearson Education Limited, 2007.
2. Anderson J.D. Computational Fluid Dynamics, Mc-Graw Hills (1995)
3. J.C. Tannehill, D.A. Anderson, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis

E-Resources:

1. <https://nptel.ac.in/courses/112105045>

INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS - LAB**Total Contact Hours: 26**

Following simulations to be done using CFD software:

1. Discretization and numerical solution of 1D steady-state heat transfer through the slab.
2. Numerical solution of a potential flow problem.
3. Solution convergence monitoring, flow visualization and post-processing techniques and tools.
4. Introduction to CFD software and setup test case-1 for laminar flow – internal and external.
5. Mesh generation for test case-1 using the inbuilt tool.
6. Grid independence test, results reporting and visualization.
7. CFD study of laminar and turbulent flow around a cylinder. Selection of different turbulent models.
8. CFD study of laminar flow past a backwards-facing step.
9. CFD study of natural convection in a square cavity.
10. CFD study of flow around airfoils.
11. CFD study of compressible flow around cylinders and cones.
12. CFD study of compressible flow around blunt bodies.
13. CFD study of flow behind a rotating cylinder.

OPERATIONS MANAGEMENT FOR AEROSPACE

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

SEMESTER – VII

Subject Code	: 20AS4706	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		

Course Learning Objectives:

This Course will enable students to:

1. **Integrate** the various elements of operations management in the context of aerospace industry.
2. **Deploy** their knowledge and skills in scheduling and control operation to address ongoing & futuristic trends in the control of inventory.
3. **Analyse** operational elements to achieve effective materials management, lean manufacturing, quality assurance and compliance.
4. **Apply** modern methods for cost reduction, digital transformation and operational efficiency in the context of the aerospace 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.

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**07 Hours****Introduction to Operations Management in Aerospace**

- Overview of aerospace industry : tier – 1, tier – 2 and tier -3
- Operations management in the aerospace industry - trends and issues.
- Importance of operations strategy, integrated product development, process design and project management in ensuring efficient production and delivery of aerospace products
- Key concepts: quality, cost, delivery effectiveness and flexibility
- Case studies of successful aerospace operations management practices

UNIT – II**08 Hours**

- Introduction to supply chain management in the aerospace industry
- Components of the aerospace supply chain: suppliers, manufacturers, distributors, and customers
- Role of forecasting, procurement, sourcing, inventory management, and logistics in the aerospace supply chain, performance measures for supply chains
- Challenges and opportunities in aerospace supply chain management

UNIT – III	08 Hours
- Production facility layout, manufacturing processes - Demand forecasting, - Enterprise Resource Planning, Inventory Planning and Control - Types of production processes: make-to-order, make-to-stock, and hybrid - JIT, KANBAN and Continuous Improvement - Material Planning, Capacity planning and resource allocation in aerospace manufacturing - Techniques for scheduling and sequencing aerospace production activities - Digital Manufacturing, Industry 4.0 and Factories of the Future	
UNIT – IV	08 Hours
- Introduction to lean manufacturing principles in aerospace operations - Operations Scheduling - Eliminating waste and improving efficiency in aerospace manufacturing - Quality assurance systems and certifications in the aerospace industry, regulatory, environmental, health and safety issues in operations (e.g., AS9100) - Tools and techniques for quality improvement in aerospace operations - Introduction to Six Sigma methodology and its applications in aerospace - Case studies of lean manufacturing and Six Sigma in the aerospace industry	
UNIT – V	08 Hours
- Regulatory environment, quality assurance - Exploration of emerging trends and technologies including digital threads and block chains in aerospace operations management - Application of analytics, artificial intelligence, and automation in factories of the future - Sustainability and environmental considerations in aerospace manufacturing and operations - Future directions and career opportunities in aerospace operations management	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Integrate production planning functions towards managing manufacturing functions	3
2	Prepare schedule and sequence for simple manufacturing operations and with affordable manufacturing lead time.	3
3	Choose supply chain strategy appropriate to the aerospace product requirements	3
4	Perform material planning, capacity planning and resource allocation for simple components	4
5	Identify and select appropriate modern operational concepts including digital manufacturing	4

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

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. B Mahadevan Operations Management Theory and Practice, 3rd Ed. 2015, Pearson Education.
2. Aswathappa K. and Sridhara Bhat, Production and Operations Management 2015, Himalaya Publishing House.

Reference Books:

1. William J Stevenson, Operations Management, 13th Ed, July 2022, McGraw Hill
2. Chary SN, Production and Operations Management, 6th Ed Tata McGraw Hill 2019

UNMANNED AERIAL VEHICLE & E-MOBILITY [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code : 20AS4707	Credits : 03
Hours / Week : 04 Hours	Total Hours : 39 Hours
L-T-P : 2-0-2	
Course Learning Objectives: This course will enable students to: - To understand roles and responsibilities for UAVs. - To identify and define aircraft systems and navigation - To understand the basics of electric vehicles, their architecture and modeling.	
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	10 Hours
Introduction to Unmanned Aircraft Systems (UAS). The Beginning The Need for Effective Control The First Modern Unmanned Aircraft; The Target Drone Some Applications of UAS, The Systemic Basis of UAS System Composition Basic Technology Control Methods. Classification of UAS Long-endurance, Long-range Role Aircraft Medium-range, Tactical Aircraft Close- range/Battlefield Aircraft; MUAV Types MAV and NAV Types, UCAV Novel Hybrid Aircraft, Configurations Research UAV	
UNIT – II	10 Hours
Introduction to Design and Selection of the System Conceptual Phase Preliminary	

Design Detail Design Selection of the System Aerodynamics and Airframe Configurations Lift-induced Drag Parasitic Drag Rotary-wing Aerodynamics Response to Air Turbulence Airframe Configurations Transportation: Micro-UAV VTOL Close-range Systems HTOL Close-range Systems Medium- range Systems MALE and HALE Systems	
UNIT – III	10 Hours
THE DEVELOPMENT OF UAV SYSTEMS Introduction to System Development and Certification System Development Certification Establishing Reliability System Ground Testing UAV Component Testing UAV Sub-assembly and Sub-system Testing Complete UAV Control Station Testing Catapult Launch System Tests Documentation System In-flight Testing Test Sites Preparation for In-flight Testing In-flight Testing System Certification	
UNIT – IV	08 Hours
Electro mobility and the Environment A Brief History of the Electric Powertrain, Energy Sources for Propulsion and Emissions, The Advent of Regulations, Drive Cycles, BEV Fuel Consumption, Range, and mpge, Carbon Emissions for Conventional and Electric Powertrains, An Overview of Conventional, Battery, Hybrid, and Fuel Cell Electric Systems, A Comparison of Automotive and Other Transportation Technologies. Vehicle Dynamics: Vehicle Load Forces, Vehicle Acceleration, Simple Drive Cycle for Vehicle Comparisons	
UNIT – V	08 Hours
Battery Management & EV Simulation Batteries Types and Battery Pack, Lifetime and Sizing Considerations, Basic Requirements for Charging System, Charging Standards and Technologies, BMS Definition, Li-Ion Cells, Li-Ion BMSs, Li-Ion Batteries, BMS Functions: Measurement: Voltage, Temperature, Current. EV Simulations: system level simulation, EV simulator, simulator modules, performance evaluation, system optimization.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Describe different phases of design of UAVs.	2
2	Describe the basic principles of UAS operation requirements and develop concept operation	2

3	Describe various E-Vehicle management systems and its simulations.	3
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COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	2	1	3	3							2		1	2	
CO2	2	1	2	2							1		1	1	
CO3	2	1	1	1							1		1	1	

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text books:

1. Reg Austin, Unmanned Aircraft systems UAVs Design, Development and Deployment, A John Wiley & Sons, Ltd., 2010.
2. Douglas M. Marshall et al., Introduction to unmanned Aircraft systems, second edition Taylor & Francis, 2016.
3. Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, G. Abas Goodarzi, 1st Edition, 2018, Wiley, ISBN 9781119063667.

Reference Books:

1. Jay Gundlach, Civil and commercial Unmanned Aircraft Systems, AIAA Education Services, 2016
2. Battery Management system for large Lithium Battery Packs, Davide Andrea, 1st Edition, 2010, ARTECH HOUSE, ISBN-13 978-1-60807-104-3
3. Hybrid Vehicles from Components to System, F. BADIN, Ed, 1st Edition, 2013, Editions Technip, Paris, ISBN 978-2-7108-0994-4.
4. Modern Electric Vehicle Technology C.C. Chan and K.T. Chau, 1st Edition, 2001, Oxford university press, ISBN 0 19 8504160.

AIRWORTHINESS & TECHNICAL PUBLICATIONS

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

SEMESTER – VII

Subject Code	: 20AS4708	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 39 Hours
L-T-P	: 2-0-2		

Course Learning Objectives:

- 1) To understand the fundamentals of aircraft and its systems and subsystems.
- 2) To understand the fundamentals and role of Aerospace Technical Publications in Aerospace Industry.
- 3) To understand Importance of Airworthiness, various Airworthiness standards, Type certificate & Production under Type Certificate.
- 4) To understand function, types, and controls of Aircraft propulsion systems.
- 5) To understand the avionics and communication system of Aircraft
- 6) To understand the various aviation quality standards which are required for Aerospace Technical Publications.

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

08 Hours

AEROSPACE TECHPUBS, AEROSPACE INDUSTRY LANDSCAPE AND MAJOR

PLAYERS:

Aerospace Techpups-Role, Life Cycle; Airworthiness Standards and Regulations, Aerospace Industry Landscape & Key Competitors, Key Sectors of Aerospace and Defense Industry, Maintenance, Repair & Overhaul (MRO), Aircraft decommissioning, Relevance to Technical publications

UNIT – II

10 Hours

KNOW YOUR AIRCRAFT

Basic terminology used in aerospace techpups. Basics of Flight - forces acting on aircraft, Lift, Weight, Thrust, Drag, Angle of attack, L/D ratio, Air foil Design, Construction. Types of Aircraft - types of aircrafts and its classification. Different Aircraft Families - Boeing Aircraft family, Bombardier Aircraft family, Aircraft Dimensions, Sections and Station Numbers.

KNOW YOUR AIRCRAFT ELECTRICAL AND LIGHTING SYSTEMS

Electrical System - AC and DC Generation, AC and DC Electrical Load Distribution, Primary and Secondary Power Distribution, Electrical Structure Network. Lighting System- purpose, exterior lights including anticollision, landing, taxi, logo, wing inspection lights. Internal Lights, Emergency lightning, Maintenance, and inspection lightning.

KNOW AIRCRAFT AVIONICS, COMMUNICATION, NAVIGATION AND INFLIGHT

ENTERTAINMENT SYSTEM

Communication System - Purpose, External Transmission, Audio Integrating and Voice Command Systems, Static Discharger. Navigation System - Air Data/Inertial Reference Systems, Standby navigation systems, Radio Altimeter (RA), Distance Measuring Equipment, Aircraft Environment Surveillance System. Inflight Entertainment System - overview on inflight entertainment system.

UNIT – III

10 Hours

AIRCRAFT DIFFERENT SYSTEM FAMILIARIZATION

Aircraft General Presentation: Introduction, Fuselage-types, Truss, monocoque, Semi-monocoque. Wings, Stabilizers, Engine, Landing Gear. Airframe - Airframe classification, Aircraft Structure- Fixed Wing, Structural stress on Aircraft, Fuselage, types, Aircraft Wing, Classification, Structure, Sub-assemblies, Ribs, stringer, Skin, Empennage, Tail, Fins and Unusual fin Configuration. Aircraft Flight controls – Primary and secondary controls. Air conditioning system - purpose, Distribution System, Pressurization Control System, Air Cooling system, Temperature Control, Moisture/Air Contaminant Control. Equipment and Furnishing - Cockpit, Passenger Compartment, Galleys, Lavatories, Additional Compartments, Emergency Equipment. Fire Protection System – Functions, Methods, Fire extinguishing methods. Flight Control System - Primary Flight Control System, Aileron, Spoiler, Elevator, Trimmable Horizontal Stabilizer, Rudder, Lift Augmenting, Flaps. Fuel system - Purpose, Storage, Distribution, Dump/Jettison, Fuel Quantity and Management System, Control and Indicating. Hydraulic System - working principle and purpose, Basic Hydraulic Systems, and its components, Open and Closed Center Hydraulic Systems, power jack, Hydraulic Systems components, Hydraulic Systems in a large Aircraft, Advantages of Hydraulics. Landing Gear - Landing Gear types and operation, Alignment, Support, and Retraction

systems, Safety Devices, Maintenance, Rigging and Adjustment, Steering Systems Aircraft wheels- construction and inspection, Brakes, Brake Actuating Systems, Aircraft Tires and Tubes, classification, construction, inspection.	
UNIT – IV	10 Hours
AIRCRAFT DIFFERENT SYSTEM FAMILIARIZATION Aircraft Oxygen System - Oxygen system, requirements, Cockpit Oxygen system, Passenger Oxygen system, Portable Oxygen System. Aircraft Pneumatic Systems - Components, bleed sources, sub systems, Distribution, Indicating, Sources of the Pneumatic systems. Water and Waste Management System - purpose, Potable water system, Toilet system, Wastewater drain. Master Warning System, List of Warnings – description, controls and indications, CAS message Window, mode and Types, master indicator lights, warning, and caution lights. Aircraft ground handling and ground equipment: Refuelling - Safety Precautions, procedure, Bonding, and grounding, refuelling vehicles, Towing, Parking, Mooring, Storage, Jacking of aircraft, Ground Support Equipment - Technical publication. AIRCRAFT POWER PLANT SYSTEMS, DISPLAYS AND CONTROLS Types of Turbine Engines - Turbojet, Turboprop, Turbofan, Turboshift Engines. Engine Systems and Controls- Cowling, Mounts, Engine, Propulsion Control System (PCS), Fuel distribution, Power Control, Air System, Ignition System, Starting, Oil System, Thrust Reverser. Control and Indicating - Engine controls.	
UNIT – V	10 Hours
STANDARDS USED IN AERO TECH-PUBS S1000D: S1000D and Commercial Aviation, Benefits, Book-Based Structures vs. S1000D Data Module. Structures, Data Module Types, From Data Modules to Publications iSpec 2200: Introduction, History, Description, Difference between ATA 100 and iSpec 2200, Deliverables of iSpec 2200, ATA SGML concept. Introduction to ATA systems: ATA overview, Usage of ATA spec, ATA system codes, Difference between ATA 100, iSpec 2100 and iSpec 2200, ATA chapters, ATA numbers and its ATA Chapter name. Introduction to ASD STE-100, Why ASD STE-100, Advantages of ASD STE 100, Writing rules, Difference between normal English and STE, Descriptive writing, Examples in STE	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the certification, aircraft registration procedures	2
2	Explain the Airworthiness requirements for different categories of aircrafts	2

3	Apply knowledge of engineering mechanics, controls, electronics, electrical and communication engineering to identify different systems instruments used in an aircraft	3
4	Examine the different systems present in an aircraft.	3
5	Apply the knowledge of aircraft standards and selecting the methods / methodology to carry out any process in aircraft.	3
6	Evaluate and interpret the Aerospace technical manuals.	4

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

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

- 1) Airworthiness: An Introduction to Aircraft Certification, 2nd Edition, ASIN: B00519EPVU, Butterworth-Heinemann, 2010.
- 2) John D. Anderson, "Introduction to Flight", McGraw-Hill Education, 2011. ISBN: 9780071108059.
- 3) Ianmoir, Allan Seabridge, "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley & Sons, 2011, ISBN 978111965008.
- 4) Lalit Gupta And O P Sharma, Aircraft Systems (Fundamentals of Flight Vol. IV), Himalayan.

REFERENCE BOOKS:

- 1) Pallet, E.H.J., Aircraft Instruments and Integrated Systems, Longman Scientific And Technical, Indian Reprint 1996.
- 2) A.C Kermode, "Flight Without Formulae", Pearson Education India, 1989. ISBN – 9788131713891.
- 3) S R Majumdar, Pneumatic Systems, Tata Mcgraw Hill Publishing Co.; 1995.
- 4) Irwin E. Treager, Gas Turbine Engine Technology, GLENCOE Aviation Technology Series, 7th Edition, Tata McGraw Hill Publishing Co. Ltd. Print 2003.

NPTEL RESEARCH METHODOLOGY

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

SEMESTER – VII

Subject Code	: 20As4709	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 39 Hours
L-T-P	: 2-0-2		

AVIATION LAW

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

SEMESTER – VII

Subject Code	: 20AS4702	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 39 Hours
L-T-P	: 2-0-2		

Course Learning Objectives:

This course will enable students to get exposed 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.

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 <i>concept can be applied to the real world</i> - and when that's possible, it helps improve the students' understanding.	
UNIT - I	08 Hours
Evolution of Aviation law: Global Perspective □ Need of Aviation law: Its scope and purposes □ Evolving aviation industry: global perspective □ Origin of Aviation law □ Situations where it is applicable (examples) □ important international conventions) Evolution of Aviation law: Indian Perspective · Its origin in colonial time · Development since then: Major amendments · Major incidents which highlighted need of stricter law, like 1999 hijacking Indian Airlines Flight 814 · Important aviation legislations in India (names only or brief info. as details will be given later in course)	
UNIT - II	05 Hours
Convention on International Civil Aviation (Chicago convention) Part 1 · Introduction: Background of the convention · Territorial jurisdiction under it · Definition/types of aircraft under it · Right of overflight. Convention on International Civil Aviation (Chicago convention) Part 2 · Int'l Civil Aviation Organisation (ICAO): Formed under the convention · Salient features · its powers and functions · other important information about it. Convention on International Civil Aviation (Chicago convention) Part 3 · Nationality of an aircraft · Traffic control (scheduled and non-scheduled traffic) · Freedoms of the air · other important information about the convention (if any) Warsaw convention · Background of the convention · its objectives and purposes · Liability of carrier in case of accident · Guadalajara Convention (supplementary to this convention) Montreal Convention · Background of the convention · Objectives and purposes · Salient features · Landmark cases Cape Town convention · Background of the convention · Aircraft protocol under it · Provisions regarding aircraft financing · other salient features	
UNIT - III	06 Hours
The Aircraft Act, 1934 · Historical background · Objectives and purposes of the act · Its salient features · Important provisions The Carriage by Air Act, 1972 · Historical background · Objectives and purposes of the act · Its salient features · Important provisions The Anti-Hijacking Act, 2016 · Historical background · Objectives and purposes of the act · Its salient features · Important provisions Aviation Law in India: Role of Judiciary · This module will cover development of case law in India regarding Aviation Law. It will track landmark judgements through the course of time.	
UNIT - IV	06 Hours
Challenges associated with crime on-board aircrafts · when is a crime said to have occurred on-board aircraft? · Problem of jurisdiction · other important issues · Examples and cases Tokyo Convention of 1963 · Introduction: Scope of convention · Jurisdiction · Powers of aircraft commander · other salient provisions Montreal Protocol, 2014 (Protocol to amend the Tokyo convention) · Introduction: Why was it needed? · Salient features · important amendments · other provisions Hague Convention, 1970 (The Anti-Hijacking Convention) · Introduction: Scope of convention · why was it introduced? · Salient features · important provisions Beijing Protocol to Hague Convention, 2010 · Introduction: Why was it needed? · Salient	

features · important provisions · other details Beijing Convention, 2010 · Introduction: Scope of convention · why was it introduced? · Salient features · important provisions	
UNIT – V	05 Hours
Recent developments · Problems in application of Air Laws · Airport management · Technological developments and law · emerging trends in Aviation Law	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand process of ethical and moral analysis in decision making scenarios and inculcate ethical behavior as a trait for professional development.	2
2	Apply the knowledge to solve practical problems with regard to personal issues & business enterprises.	3
3	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.	3

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

CO4	3	2						1	1	1	1		1		
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3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

SATELLITE TECHNOLOGY [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Subject Code : 20AS4704	Credits : 03
Hours / Week : 04 Hours	Total Hours : 39 Hours
L-T-P : 2-0-2	
<u>Course Learning Objectives:</u> This course will enable students to get exposed to: 1. Different types of Satellites & Payloads and their applications, Mission Planning, Selection of suitable payloads and sensors for various missions & applications 2. Mainframe Subsystems and Payloads, Mechanical, Propulsion, Thermal and Electrical Subsystems of satellite such as Power, Telemetry, Telecommand, Control Electronics, Sensors, Communication, Data Handling System & Solid State Recorder 3. Spacecraft configuration, spacecraft architecture, accommodation studies and functions of subsystems 4. Spacecraft Systems Engineering, Assembly, Integration & Testing (AIT) towards satellite realisation, subsystems integration, system level testing and facilities for testing 5. Navigation, Guidance and Control (NGC), Mission Software, Reliability & Quality Assurance (R&QA), Safety Aspects 6. Practical Experiments using CANSAT (Satellite in a Can), Class Room Model Cubesat - Mechanical, Thermal and Electrical Aspects	
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	08 Hours
Types of Satellites & Payloads, Cubesats Overview of Space Environment, Classification of satellites, Types of Orbits, Types of Payloads & Applications, Cubesat Configuration, Payloads for Cubesats, Spacecraft System Engineering - Concepts, Overview of Launch and On-Orbit Operations, Life-Cycle of Satellites, Space Policies & Laws.	
UNIT – II	05 Hours
Spacecraft Bus and Payload Systems: Overview, Model philosophy, Spacecraft configuration, Bus and payload systems requirements, Mechanical and Electrical requirements, Thermal requirements, Accommodation Studies and optimisation, Layouts and ILDs (Inserts Layout Drawings) generation	
UNIT – III	06 Hours
Spacecraft Mainframe Subsystems Mainframe Subsystems-Mechanical: Structure, Propulsion, Thermal and Deployment Mechanisms; Electrical: Power, Telemetry, Telecommand, Control Electronics, Sensors, Communication, Data Handling System & Solid State Recorder	
UNIT – IV	06 Hours
System View of Spacecraft, Space systems architecture: ground, launch and space segments, Subsystems	

integration and testing, Systems Level testing, Facilities for Spacecraft Testing, Spacecraft realisation, Pre-launch Operations at launch Base	
UNIT – V	05 Hours
Navigation, Guidance and Control (NGC) software, Mission Software, Overview of Reliability & Quality Assurance (R&QA), Reliability in Parts, Materials and Processes, Product Assurance in Manufacturing and AIT, Safety Aspects	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Configure any type of satellites and payload selection to meet the user requirements	2
2	Use Spacecraft Systems Engineering Concepts for Assembly, Integration and Testing (AIT), Systems Level testing, Spacecraft Realisation, Pre-launch Operations at launch Base	3
3	Spacecraft software, R&QA and Spacecraft Safety Aspects	3
4	Design, Development and Deployment of Student satellite	3

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

CO4	3	3	2	1							1		1		
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Text Books

1.Spacecraft Systems Engineering, 4th Edition, Peter Fortescue (Editor), Graham Swinerd (Editor), John Stark (Editor), Wiley Publication, ISBN: 978-0-470-75012-4 September 2011, 728 pages

2. Quintessence of Nano-satellite Technology, Planet Aerospace India, Notion Press.com , 2020, INDIA

References

1.Low Earth Orbit Satellite Design, Authors: Steve Fujikawa, Nicholas Galassi, Alex Chuchra, George Sebestyen, Space Technology Library ISBN 978-3-319-68314-0 ISBN 978-3-319-68315-7 (eBook) <https://doi.org/10.1007/978-3-319-68315-7> Library of Congress Control Number: 2017955031 © Springer International Publishing AG, 6 February 2018, 320 pages

2.Fundamentals of Space Systems, (Johns Hopkins University Applied Physics Laboratories Series in Science and Engineering) 2nd Edition, Vincent L. Pisacane (Editor), Robert C. Moore (Editor), ISBN 0-19- 507497-1, Oxford University Press Inc.1994, 788 pages

3.CubeSat Handbook: From Mission Design to Operations, Authors: Chantal Cappelletti, Simone Battistini, Benjamin Malphrus, ISBN-978-0-12-817884-3, Publisher: Elsevier, Sept. 2020, 500 pages

LIST OF EXPERIMENTS:

1. Demonstration of Relation between Frequency and period
2. Frequency measurements through oscillation method
3. Damping measurements through decay method
4. CG measurements by suspension method
5. CG measurement by reaction force
6. CG measurement by knife edge
7. CG measurement by bending method
8. Stress measurements
9. MI measurements by torsional method
10. Importance of Pre-loading and techniques
11. Aerospace Materials Selection and Parameters Comparison
12. Preload adjustment for satellite handling
13. Simulation of Thermal, structural analysis for 4 different subsystems
14. Measurement of input and output parameters of power supply module of satellite

15. Functioning of OBC module of satellite
16. Functioning of Communication system
17. Functioning of Available payload system
18. Overall functioning and noting of various parameters of satellite (Cubesat)
19. Commanding satellite (Class Room Model) remotely for different functions like antenna
20. Deployment Mechanism, Payload subsystem etc.
21. Ground station operations
22. Receiving signals from satellite(s)
23. Analysis of received signals

TECHNICAL REPORT WRITING [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – III			
Subject Code	: 20AS4705	Credits	: 01
Hours / Week	: 02 Hours	Total Hours	: 26 Hours
L-T-P-S	: 0-0-2-0		
<u>Course Learning Objectives:</u> This course will enable students to: 1. Analyze and interpret technical information using the diction and design layout of written technical communication. 2. Write assignments and projects that will include a variety of business and technical applications and report writing. 3. Prepare an oral briefing and engage in group projects that will promote critical thinking and teamwork.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teachers 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, note taking, annotating, and roleplaying. 3. Show Video/animation films to explain the 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.	
Course Content	
	26 Hours
Essentials of Technical Communication, Different kinds of written documents: Definitions – descriptions – instructions – recommendations - manuals -reports – proposals	
Technical paper writing: Library research skills, documentation style - document editing – proofreading - Organising and formatting	
Mechanics of Writing: Modifiers, phrasal verbs, tone and style, graphical representation	
Reading and listening comprehension of technical documents	
Mini Technical project (10 -12 pages)	
Practice in oral communication and Technical presentations.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Organize material in a professional, logical, and aesthetically pleasing format using concise, clear language.	L2
2	Analyze technical writing documentation and make improvements in form, content, and readability.	L2 & L3
3	Use the library and internet recourses for research purposes	L2
4	Demonstrate the ability to communicate orally by giving a presentation on a technical writing issue, using handouts, slides, or any other visuals	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	3
C01										3					
C02										3					
C03										3		1			
C04									2	3		1			

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

REFERENCE BOOKS:

- Hirsh, Herbert. L "Essential Communication Strategies for Scientists, Engineers and Technology Professionals". II Edition. New York: IEEE press, 2002
- Anderson, Paul. V. "Technical Communication: A Reader-Centred Approach". V Edition. Harcourt Brace College Publication, 2003

4. Strunk, William Jr. and White. E B. "The Elements of Style" New York. Alliyen & Bacon, 1999.
5. Riordan, G. Daniel and Pauley E. Steven. "Technical Report Writing Today" VIII Edition (Indian Adaptation). New Delhi: Biztantra, 2004.

E-Resources:

- 1.

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 the solution to a problem through programming.

VIII SEMESTER

HELICOPTER DYNAMICS			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VIII			
Subject Code	: 20AS4802	Credits	: 0
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: This course will enable students to: 1. Comprehend the basic concepts of helicopter dynamics 2. Acquire the knowledge of critical speed and rotor bearing systems 3. Understand the turbo rotor system and blade vibration.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teachers 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, note taking, annotating, and roleplaying. 3. Show Video/animation films to explain the 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.			
Course Content			
UNIT 1			08 Hours
Introduction: History of helicopter flight. Fundamentals of Rotor Aerodynamics; Momentum theory analysis in hovering flight. Disk loading, power loading, thrust and power coefficients. Figure of merit, rotor solidity and blade loading coefficient. Power required in flight. Axial climb, descent, and autorotation. Blade element analysis in hovering and			

forward flight. Rotating blade motion, Types of rotors

UNIT – II	08 Hours
Basic Helicopter Performance: Forces acting on helicopters in forward flight. Methods of achieving translatory flight. Controlling cyclic pitch: Swash-plate system. Lateral tilt with and without coning. Forward flight performance- total power required, effects of gross weight, effect of density altitude. Speed for minimum power, and speed for maximum range. Factors affecting forward speed, and ground effects.	
UNIT – III	05 Hours
Rotor Airfoil Aerodynamics: Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics, high angle of attack range. Rotor Wakes and Blade Tip Vortices: Flow visualization techniques, Characteristics of rotor wake in hover, and forward flight. Other characteristics of rotor wake.	
UNIT – IV	06 Hours
Helicopter Stability and Control: Introductory concepts of stability. Forward speed disturbance, vertical speed disturbance, pitching angular velocity disturbance, side-slip disturbance, yawing disturbance. Static stability of helicopters: longitudinal, lateral directional and directional. Dynamic stability aspects, Main rotor and tail rotor control, Flight and Ground Handling Qualities-General requirements and definitions. Control characteristics, Levels of handling qualities.	
UNIT – V	06 Hours
Standards and Specifications: Scope of requirements. General and operational requirements, Military derivatives of civil rotorcraft. Structural strength and design for operation on specified surfaces, Conceptual Design of Helicopters: Overall design requirements. Design of main rotors-rotor diameter, tip speed, rotor solidity, blade twist and aerofoil selection, Fuselage design, Empennage design, Design of tail rotors	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Apply the basic concepts of helicopter dynamics.	L2
2	Compute the critical speed by using various methods.	L2 & L3
3	Distinguish the turbo rotor system stability by using transfer matrix and finite element formulations.	L2

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	2								1		1	1	
CO2	2	1	1	3									1	1	
CO3	3	1											1	2	

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. J. Gordon Leishman, Principles of Helicopter Aerodynamics, Cambridge University Press, 2002.
2. George H. Saunders, Dynamics of Helicopter Flight, John Wiley & Sons, Inc, NY, 1975.

Reference Books:

1. W Z Stepniewski and C N Keys, Rotary Wing Aerodynamics, Dover Publications, Inc, New York, 1984.
2. ARS Bramwell, George Done, and David Balmford, Helicopter Dynamics, 2nd Edition, Butterworth-Heinemann Publication, 2001.
3. John, M. Seddon and Simon Newman, Basic Helicopter Aerodynamics, Wiley, 2011.
4. Gareth D. Padfield, Helicopter Flight Dynamics, 2nd Edition, Wiley, 2011.

AIRCRAFT MAINTENANCE, OVERHAUL AND REPAIR

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

SEMESTER – VIII

Subject Code	: 20AS4803	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:

This course will enable students to:

1. Comprehend the fundamentals of maintenance and certification.
2. Acquire the knowledge of documentation for maintenance.
3. Understand the Aircraft Maintenance, safety and trouble shooting.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teachers 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, note taking, annotating, and roleplaying.
3. Show **Video/animation** films to explain the 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.

Course Content

UNIT 1	26 Hours
Types of maintenance, Redesign, Failure rate pattern, other maintenance considerations. Aviation industry certification requirements, Type certificate (FAA form 8110.9), Airworthiness certificate (FAA form 8100-2), Aviation maintenance certifications, General, Airframe, Powerplant, Avionics courses.	

UNIT – II	08 Hours
Documentation for Maintenance Manufacturers documentation, Airplane maintenance manual, Fault insulation manual, illustrated parts catalogue, structural repair manual, wiring diagram manual, Master minimum equipment, Federal Aviation regulation (FAR), Advisory circulars, Airworthiness direction ATA document standards, Technical policies and procedure manuals(TPPM), calibration manual, Directorate General of Civil Aviation (DGCA)	
UNIT – III	05 Hours
Structure, Role of aviation management, Line supervisory management, Management areas of concern in airlines, Manager of overhaul shops, Line maintenance control center flight line (preflight & post flight), Aircraft Logbook, daily check on major components of aircraft depending on airframe (flying) hours or calendar life, Maintenance crew skill requirements. First Flight Servicing (FFS), Turn Round Servicing (TRS), Last Flight Servicing (LFS), Types of maintenance bases	
UNIT – IV	06 Hours
Introduction, organization of hanger maintenance, Non- routine item, parts availability, cannibalization, Types of shops- sheet metal shop, Aircraft interior shop, Engine shop, Avionics shop, ground support equipment and ground handling equipment, outsourcing of shop maintenance work, operation of overhaul shops, Material support, Material management inventory control, Support functions of material, Parts ordering, Storage, Issue, control and handling, Parts receiving quality control, calibration program, stock level adjustments, shelf life, exchanges, warranty & modifications of parts, spares management, approved bonded stores for airborne items.	
UNIT – V	06 Hours
FOD, Safety regulations, Role of ATC. Tarmac discipline and management, occupational safety and health standards maintenance safety program, Airlines safety management, General safety rules, Accident & injury reporting, Hazardous materials storage and handling aircraft furnishing practices trouble shooting, repeated snags, rectifications, modifications on aircraft and release of mod leaflets, Knowledge of malfunctions.	

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Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Maintain the aircraft maintenance manual and logbook.	L2
2	Do the quality control and calibration.	L2 & L3
3	Incorporate the safety regulations and rules.	L2

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	2	2								1		1	1	
C02	2	1	3								1		1	1	
C03	3	1											1	2	

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

Text Books:

1. Harry A Kinnison, Tariq Siddiqui, Aviation Maintenance Management, Mc Graw Hill education (India) Private Ltd 2013.
2. Kroes, Watkins, Delp, 'Aircraft maintenance and repair', Mc Graw Hill, 2013.

Reference Books:

1. Larry Reithmaier "Aircraft Repair Manual"; Palmar Books, Marquette, 1992.
2. Brimm. DJ, Bogges, HE, Aircraft Maintenance, Pitman publishing corp, London, 1952.

NPTEL - RESEARCH METHODOLOGY

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

SEMESTER - VIII

Subject Code	: 20AS4804	Credits	: 03
Hours / Week	: 04 Hours	Total Hours	: 39 Hours
L-T-P	: 2-0-2		



Dayanand Sagar University

SCHOOL OF ENGINEERING



SCHEME & SYLLABUS

3rd & 4th Semesters

2022-2026 Batch

With Effect from 2023-24

(Academic Year 2023-24)

SCHEME 2022 – 2026 Batch

III SEMESTER

S.N	Program Code	COURSE CODE	Course Name	Teaching Hours / Week				Examination				Credits
				Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
				L	T	P	J					
1	101	22AS2301	Math Foundations – III	3	0	0	0	3	60	40	100	3
2	101	22AS2302	Thermodynamics and Heat Transfer	3	0	0	0	3	60	40	100	3
3	101	22AS2303	Introduction to Aerospace Engineering	2	0	0	0	3	60	40	100	2
4	101	22AS2304	Fluid Mechanics	3	0	2	0	5	60	40	100	4
5	101	22AS2305	Aerospace Structural Mechanics	3	0	2	0	5	60	40	100	4
6	101	22AS2306	Aerospace Materials	3	0	2	0	5	60	40	100	4
7	101	22AS2307	Special Topics - I	1	0	0	0	1	60	40	100	1
8	101	22AS2308	Skill Enhancement Course – I	0	0	2	0	2	60	40	100	1
			Total	18	0	8	0	27	480	320	800	22

IV SEMESTER

S. N	Program Code	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	101	22AS2401	Math Foundations -IV (Statistics, Probability)	MAT	3	0	0	0	3	60	40	100	3
2	101	22AS2402	Aerospace Manufacturing	ASE	3	0	2	0	5	60	40	100	4
3	101	22AS2403	Introduction to Space Technology	ASE	3	0	0	0	3	60	40	100	3
4	101	22AS2404	Aircraft Propulsion	ASE	3	0	0	0	3	60	40	100	3
5	101	22AS2405	Low-speed Aerodynamics (New course introduced)	ASE	3	0	0	0	3	60	40	100	3
6	101	22AS2406	Introduction to Computational Fluid Dynamics (New course introduced)	ASE	2	0	2	0	5	60	40	100	3
7	101	22AS2407	Special Topics -II	Respective Dept.	1	0	0	0	1	60	40	100	1
8	101	22AS2408	Skill Enhancement Course – II	Respective Dept.	0	0	2	0	2	60	40	100	1
			Total		18	0	6	0	21	480	320	800	21

MATH FOUNDATIONS – III

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

SEMESTER – III

Course Code	: 22AS2301	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.

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 :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 of partial differential equations (PDEs) such as elliptic, parabolic, and hyperbolic equations.	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	2	1					1					
CO2	3	2	2						1					
CO3	3	2	2	1					1					
CO4	3	2	2	1					1					
CO5	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>

THERMODYNAMICS AND HEAT TRANSFER

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

SEMESTER – III

Course Code	: 22AS2302	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** thermodynamic laws to open and closed systems
2. **Analyze** phase change of pure substances.
3. **Apply** thermodynamic laws to heat engines, heat pumps and refrigerators.
4. **Derive** fundamental relations between thermodynamic properties.
5. **Apply** ideal cycle analysis to Otto, Diesel, Bryton cycle and refrigeration cycles.
6. **Analyze** the different heat transfer mechanisms.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teachers 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, note taking, annotating, and roleplaying.
3. Show **Video/animation** films to explain the 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.

Course Content

UNIT – I

08 Hours

Basic Concepts of Thermodynamics:

Introduction- Basic Concepts: System, Control Volume, Surrounding, Boundaries, Universe, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, Thermodynamic properties: definition and units. Intensive and extensive 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), irreversible process, causes of irreversibility, Zeroth law of thermodynamics statement, Concept of Temperature and its measurement, Temperature scales.

UNIT – II		08 Hours
<i>First Law of Thermodynamics:</i>		
Forms of energy, Heat and Work, types of work, First Law of Thermodynamics, energy balance, energy change of a system, energy and environment. Application of the first law of thermodynamics to a closed and open system, Internal energy and enthalpy, specific heats, energy as a property, Steady Flow Energy Equation, Application of SFEE, Properties of Pure Substances, phases of a pure substance, property diagrams for phase change process of pure substance.		
UNIT – III		08 Hours
<i>Second Law of Thermodynamics:</i>		
Limitations of the first law of thermodynamics, Thermal reservoirs, Heat engines, Thermal Efficiency, reversed heat engine, Refrigerator and Heat Pump, Coefficient of Performance, Kelvin-Planck and Clausius statement of the second law of thermodynamics, Equivalence of the two statements, reversible and irreversible processes, Carnot theorem and its corollaries. Entropy, an increase of entropy principle; third law. Entropy change for ideal gases. The Tds relations, general relations for du, dh, ds, specific heats		
UNIT – IV		08 Hours
<i>Gas Power and Refrigeration Cycles:</i>		
Ideal Cycles - Otto cycle, Diesel cycle and Joule-Brayton cycle: Refrigeration Cycles: Vapor compression refrigeration, air refrigeration cycles. Open cycle aircraft cooling system.		
UNIT – V		07 Hours
<i>Introduction to Heat Transfer:</i>		
Thermodynamics and Heat Transfer, Applications, Historical background, Heat transfer modes, Conduction, Fourier law, Thermal conductivity, diffusivity, Convection; Newton's law of cooling, Radiation heat transfer, Simultaneous heat transfer mechanisms, Overall heat transfer coefficient.		

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Use Zeroth law of thermodynamics to analyze temperature scales.	L2
2	Analyze the work and heat interactions and perform first law analysis of various processes.	L2 & L3
3	Apply the second law of thermodynamics and entropy concepts for analyzing heat engines, refrigerators and heat pumps	L2 & L3
4	Apply ideal cycle analysis to heat engine and refrigeration cycles to determine performance parameters.	L2 & L3

5	Apply governing laws of conduction, convection and radiation heat transfer to determine heat transfer rate and temperature.	L2 & L3
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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									1	3		
C02	3	2													
C03	3	2	1									1	2		
C04	3	3	2	1	2		1					1	3		
C05	3	1											2		
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)							

TEXT BOOKS:

1. Cengel, Y., and Boles, M., "Thermodynamics: An Engineering Approach", 9th Ed., McGraw Hill, 2018
2. Sonntag, R. E., Borgnakke, C. and Van Wylen, G. J., "Fundamentals of Thermodynamics", 6th ed., Wiley, 2002

REFERENCE BOOKS:

1. Nag, P. K., "Engineering Thermodynamics", 4th ed., Tata McGraw Hill, 2008
2. Cengel, Y., and Ghajar, "Heat transfer: A practical approach", McGraw Hill, 2nd Ed., 2002
3. Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey, "Fundamentals of Engineering Thermodynamics", 9th Edition, Wiley, 2018

E-Resources:

1. <https://www.coursera.org/learn/thermodynamics-intro>
2. <https://nptel.ac.in/courses/127106135>

INTRODUCTION TO AEROSPACE ENGINEERING			
SEMESTER – III			
Course Code	: 22AS2303	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		
<u>Course Learning Objectives:</u>			
This course will enable students to:			
1. Understand the History and Development of Aviation: Students will gain knowledge of the history of aviation, including the key milestones, influential figures, and significant technological advancements that shaped the field. 2. Comprehend Aerodynamic Principles and Aircraft Performance: Students will learn the fundamental principles of aerodynamics and their application to aircraft design. 3. Familiarize with Aerospace Systems and Technologies: Students will be introduced to various aerospace systems and technologies, including flight control surfaces, engines (piston, jet, and rocket engines), flight and navigation instruments, hydraulic and pneumatic systems, electrical systems, and fuel, fire, ice, and rain protection systems. 4. Familiarize with Aerospace Systems and Technologies: Students will be introduced to various aerospace systems and technologies, including flight control surfaces, engines (piston, jet, and rocket engines), flight and navigation instruments, hydraulic and pneumatic systems, electrical systems, and fuel, fire, ice, and rain protection systems.			
1. Teaching-Learning Process (General Instructions) 2. These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. 3. 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. 4. Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 5. Show Video/animation films to explain functioning of various concepts. 6. Encourage Collaborative (Group Learning) Learning in the class.			

7. To make <i>Critical thinking</i>, ask at least three Higher order Thinking questions in the class. 8. Adopt <i>Problem Based Learning</i>, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. 9. 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. 10. Discuss how every <i>concept can be applied to the real world</i> - and when that's possible, it helps improve the students' understanding.	
UNIT – I	08 Hours
INTRODUCTION TO AEROSPACE ENGINEERING Introduction to Aerospace Engineering: History of aviation, Atmosphere, Classification of aircraft, Aircraft Nomenclature, Flight control surfaces, Modern developments in Aviation Aerospace industry and career opportunities, Applications, Global need for aerospace engineers Introduction to Space Flight: Space and its properties, History of Space Flight & spacecraft technologies, Types of orbits and Introduction to orbital mechanics	
UNIT – II	08 Hours
FUNDAMENTALS OF FLIGHT AERODYNAMICS Fundamentals of Flight Aerodynamics: Basics of Aerodynamics, Basics of Aerodynamics, Lift and Drag, Monoplane, Biplane and Triplane, Advantages and Disadvantages, Nomenclature of Airfoils, Aerodynamic Force and Moment Coefficients, lift and drag variations, types of drag, factors affecting lift and drag, Centre of pressure and aerodynamic centre, Basic characteristics of airfoils, Reynolds number, Significance of speed of sound, Propagation of sound, Mach number, Features of subsonic, transonic, supersonic, hypersonic flows.	
UNIT – III	06 Hours
AIRCRAFT PROPULSION & ROCKET PROPULSION Introduction, Piston engines and Jet engines, Brayton cycle, Components of the basic jet engine and performance characteristics, Principles of operation of Turboprop, turbojet and turbofan engines, P-V and T-S Diagrams of the basic cycle, Intercooler, Regeneration and Reheat, Thermal efficiency, Introduction to ramjets and scramjets, Principles of rocket propulsion, Classification of Rockets, Specific impulse	
UNIT – IV	09 Hours

AIRCRAFT INSTRUMENTS & AIRCRAFT SYSTEMS

Introduction to Flight and Navigation Instruments, Basic Air data systems & Probes, Mach meter, Airspeed indicator, Vertical speed indicator, Altimeter, Gyro based instruments. Introduction to Hydraulic, Pneumatic and Electrical systems on aircraft, Air Conditioning and Cockpit pressurization system, Generation and distribution of electricity on board the aero plane, Aircraft Fuel System, Fire Protection, Ice and Rain Protection System.

UNIT – V**08 Hours****ADVANCEMENTS IN THE AEROSPACE INDUSTRY**

Applications of lasers, Advancements in the aerospace industry, Introduction to Satellite Systems, applications and use cases, Miniaturized Satellite Systems, Drone Technology and Applications, Heli taxi, cargo and future aviation industry, defence sector, Submarines and UVSS, CubeSat Mission Planning and Operations, revenue model, country economy, private players in the aerospace industry, space explorations, space debris, Reusable Rockets, Space telescopes, AI & Digital twin technology, Super pressure Balloons, case studies

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Outline historical developments in the aerospace industry and classify aircrafts and spacecraft	L2 & L3
2	Calculate aerodynamic coefficients and classify different flow regimes	L2 & L3
3	Compare the working of different aircraft and rocket propulsion systems.	L2 & L3
4	Asses various aircraft instruments and systems	L2 & L3
5	Outline recent advances in aerospace industry	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	3
C01	3	3		2	3							2		3	
C02	3	3	2	3	3							2		3	
C03	3	3		3	3							1		3	
C04	3	3	2	2	3							2		3	
C05	3	3			2							1		3	

TEXTBOOKS:

1. John D. Anderson, "Introduction to Flight", McGraw-Hill Education, 8th edition, 2015, ISBN: 978-0078027673.
2. E Rathakrishnan, Theoretical Aerodynamics, 2013 Edition, John Wiley & Sons, Singapore

REFERENCE BOOKS:

1. Ian Moir, Allan Sea bridge, "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley & Sons, 3rd edition, 2011, ISBN: 9781119965206.
2. Sutton G.P., "Rocket Propulsion Elements", John Wiley, New York, 9th edition, 2016, ISBN: 9781118753910.
3. A.C. Kermode, "Flight without formulae", Pearson Education India, 5th edition, 1989, ISBN: 9788131713891.
4. Nelson R.C., "Flight stability and automatic control", McGraw-Hill, 2nd edition, 1998, ISBN: 9780071158381.
5. T.H.G Megson "Introduction to Aircraft Structural Analysis", Elsevier Exclusive Publications, 2nd edition, 2014, ISBN 13: 978-9351071860.

FLUID MECHANICS [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – III	
Course Code : 22AS2304	Credits : 03
Hours / Week : 03 Hours	Total Hours : 39 + 26 Hours
L-T-P : 3-0-2	
Course Learning Objectives: This Course will enable students to: 1. Analyze the incompressible fluid flow by different governing equations 2. Explain the basic properties of fluids , and hydrostatic forces. 3. Understand dimensional analysis and its application. 4. Describe the boundary layer flow of fluid.	
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	08 Hours
INTRODUCTION: Introduction, properties of fluids, surface tension and capillarity. Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmospheric and vacuum pressures, simple manometers. Application area of fluid mechanics	
FLUID STATICS: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid. Hydrostatic forces on submerged plane surface, horizontal, vertical	

UNIT – II	08 Hours
FLUID FLOW: Lagrangian and Eulerian descriptions, Types of flows, Continuity equation, velocity and acceleration, velocity potential function, FLUID KINEMATICS Stream function, lines of constant stream function and equipotential line, Streamline, Path line, and Streak line, Circulation, Vorticity	
UNIT – III	06 Hours
MODULE -3: FLUID DYNAMICS AND FLOW MEASUREMENT Introduction, Euler's Equation of motion, Assumptions, Bernoulli's equation, Bernoulli's equation for real fluids and application, Measurement of flow, venturimeter, orifice meter, pitot tube	
UNIT – IV	09 Hours
MODULE -4: DIMENSIONAL ANALYSIS Introduction, Dimensional homogeneity – Raleigh and Buckingham theorems – Non Dimensional numbers – Model laws and distorted Models-Unit Quantities-Specific Quantities.	
UNIT – V	08 Hours
MODULE -5: BOUNDARY LAYER THEORY Equation of motion in differential form, Viscous flow, exact solutions, pipe flow. Laminar boundary layers. Boundary layer solution methods. Introduction to Turbulence, Reynolds averaging	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply Pascal law to determine the pressure variation.	L2 & L3
2	Apply governing laws to different types of fluid flows and determine variation of pressure and velocity for different boundary conditions.	L2 & L3
3	Use the concepts of dimensional homogeneity, and similitudes and determine various non-dimensional quantities.	L2 & L3
4	Apply Euler's Equation and Bernoulli's equation to determine flow parameters in flow measuring devices-venturi meter, orifice meter and rotometer.	L2 & L3
5	Determine stream function, circulation and vorticity.	L2 & L3
6	Apply the boundary layer theory to determine turbulence parameters	L2 & L3
7	Determine the head loss in pipes and bends	L3 & 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	3
C01	3	3											1		
C02	3	3			1								1		
C03	3	3			1				3	3			1		
C04	3	3											1		
C05	3	3											1		
C06	3	3											1		
C07	3	3			1				3	3			1		
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)					

TEXT BOOKS:

1. White, F. M., "Fluid Mechanics (SI Units)", 7th Ed., Special Indian Edition, McGraw Hill, 2011.
2. Cengel, Y. A., Cimbala, J. M., "Fluid Mechanics (Fundamentals and Applications)", 2nd Ed., Tata McGraw Hill, 2010

REFERENCE BOOKS:

1. Dr. R.K. Bansal, (2000), "Fluid Mechanics and Hydraulic Machines", Laxmi Publication (P) Ltd., New Delhi.
2. P.N. Modi and S.M. Seth (1999), "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, Naisarak, Delhi
3. Panton, R. L., "Incompressible Flow", 3rd Ed., Wiley India Edition, 2006.

E-Resources:

1. <https://archive.nptel.ac.in/courses/112/105/112105171/>
2. <https://www.vlab.co.in/participating-institute-nitk-surathkal>

FLUID MECHANICS LABORATORY

Total Contact Hours: 26

Following are experiments to be carried at fluid mechanics laboratory

1. Determination of the Co-efficient of Discharge of the given Orificemeter
2. Determination of the Co-efficient of Discharge of the given Venturimeter
3. Co- Efficient of Discharge of the Given Notch Apparatus
4. Calculation of The Rate of Flow Using Rotameter
5. Pipe Friction Apparatus
6. Loss of Head on Pipe Fittings Apparatus

AEROSPACE STRUCTURAL MECHANICS

SEMESTER – III

Course Code	: 22AS2305	Credits	: 04
Hours / Week	: 03 Hours	Total Hours	: 39 + 26 Hours
L-T-P	: 3-0-2		

Course Learning Objectives:

This course will enable students to:

1. **Analyze** the behaviour of aerospace structures under different loading conditions
2. **Apply principles** of structural analysis to determine the stress, strain, and deformation of aerospace components and systems.
3. **Evaluate** the performance and safety of aerospace structures by conducting structural integrity assessments and failure analyses.
4. **Interpret** and **analyze** experimental data obtained from structural tests, such as material testing, load testing, and vibration analysis.

1. Teaching-Learning Process (General Instructions)

2. These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.
3. **Lecture method** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
4. **Interactive Teaching: Adopt the Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
5. Show **Video/animation** films to explain functioning of various concepts.
6. Encourage **Collaborative** (Group Learning) Learning in the class.
7. To make **Critical thinking**, ask at least three Higher order Thinking questions in the class.
8. 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.
9. Show the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

10. 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

FLIGHT VEHICLE STRUCTURES

Principles of structures construction: Materials, Properties of material, material selection for aerospace structure applications, Analysis of aircraft structures, loads on structural components and their function, structures, fabrication, airworthiness and airframe loads, fatigue.

UNIT – II

08 Hours

BASIC STRESS ANALYSIS

Concepts, types of stresses and strains, Stress-strain relations in 1D, 2D, and 3D, Plane stress and strain, Principal stresses, Lateral strain, Poisson's ratio and volumetric strain, Elastic moduli

UNIT – III

06 Hours

STRESSES IN BEAMS

Definition of beam - Types of beams, loads and reactions, Shear force and Bending moment and their diagrams, bending stress, shear stress and deflection in the beam

UNIT – IV

09 Hours

TORSION

Torsion of a solid section, hollow sections and thin-walled sections. Shear Centre torsion equations

UNIT – V

08 Hours

STRUCTURAL DESIGN PRINCIPLES

Buckling and stability, critical load, Euler's column theory, types of end condition, combined bending and torsion, Equivalent stress, Working stress, a factor of safety, failure theories, analysis of composite materials

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Determine loads on aircraft structural members and select appropriate material.	L2 & L3
2	Analyze the axial members for stress, strain and deformation	L2 & L3
3	Construct Shear force and bending moment diagrams and calculated bending and shear stresses in beams.	L3 & L4
4	Analyze the torsional members for stress, strain and deformation.	L3 & L4
5	Determine critical load for columns with different end conditions.	L2 & L3
6	Apply the theories of failure in designing the structures	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	3
C01	3	3		2	1								3		
C02	3	3	2	3	2				2	2			2		
C03	3	3		3	2				2	2		1	2		
C04	3	3	2	2	2				2	2		1	2		
C05	3	3		2	2				2	2		1	2		
C06	3	3		2	2								2		

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. T.H.G.Megson, Aircraft Structures for Engineering students, Elsevier. 5th edition, 2007.
2. Lalit Gupta and O P Sharma, Fundamentals of Flight Vol-II (AIRCRAFT STRUCTURES), Himalayan Books. 2006, ISBN: 9788170020752

REFERENCE BOOKS:

1. J.B.K. Das and Dr. P.L.Srinivas Murthy , "Mechanics of Materials", Sapna, 2016.
2. Barry J Goodno, James M Gere, Mechanics Of Materials, 9th Edition, Cengage Publications

E-Resources:

1. <https://archive.nptel.ac.in/courses/101/105/101105084/>

Activity-Based Learning (Suggested Activities in Class)

1. Group discussions on finding the root causes of failure of aircraft component
2. Video demonstrations on building a spacecraft and group discussions

AEROSPACE STRUCTURES LABORATORY

Total Contact Hours: 26

The following are physical experiments to be carried out

1. Column Test: The column test is carried out to study the behaviour of structural columns under axial loads.
2. Deflection of Beams: This experiment involves studying the deflection behaviour of beams under different loads.
3. Thin and Thick-Walled Pressure Vessel: This experiment involves analyzing the behaviour of pressure vessels subjected to internal or external pressure.
4. Photoelastic Test: The photoelastic test is used to analyze stress distribution in transparent materials.
5. Fatigue Testing: Fatigue testing is performed to assess a material's resistance to repeated or cyclic loading.
6. The vibration of Beams: This experiment involves studying the vibration characteristics of beams subjected to dynamic loads.
7. Creep Testing Machine: The creep testing machine is used to evaluate a material's behaviour under long-term constant stress or load.
8. Pin Jointed Frames Analysis: This experiment involves analyzing the structural behaviour of pin-jointed frames subjected to various loads.
9. Determinate Beam Structure: This experiment involves analyzing statically determinate beam structures subjected to different loads
10. Case study of the failure of aircraft structures

AEROSPACE MATERIALS

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

SEMESTER – III

Course Code	: 22AS2306	Credits	:4
Hours / Week	: 03 Hours	Total Hours	: 39+ 24 Hours
L-T-P	: 3-0-2		

Course Learning Objectives:

This Course will enable students to:

1. **Analyze** the different material requirements which are intended to global aerospace industry and market
2. **Devise** the testing of different materials and apply the same based on strength and durability criteria's.
3. **Explain** the time temperature relationship and different types of heat treatment processes for different metal and alloys and concepts of corrosion in materials
4. **Get the idea** of basic principles of metallurgy, advanced materials for jet engine applications and thermal barrier coating applications.
5. **Describe** and illustrate different materials for composites materials manufacturing and introduction of materials for additive manufacturing, aerospace, marine, automotive and domestic applications.

1. Teaching-Learning Process (General Instructions)

2. These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.
3. **Lecture method** for this course includes presentation which includes **chalk and talk for all modules**.
4. **Interactive Teaching:** *The adoption of Active learning via brainstorming for module 1 and 2 are of group discussion which is based on selection of materials for different applications.*
5. The concept in each and every module consists of **video animations** which utilises virtual labs for testing of materials.
6. The **collaborative learning** which will be group oriented which involves development of composites materials using different fabrication techniques.
7. The **Critical thinking** is adopted considering time and temperature transformation diagram which is of different measures for different materials
8. Adopt **Problem Based Learning**, in this course is based on solving numerical based on strength and durability testing of materials which will be experimentally and theoretically validated.

9. Different methods of solving problems involves different case studies based on wings,etc in an aircraft. 10.Discuss how every <i>concept can be applied to the real world</i> –In this courses an attempt is made for a development of wing structure via concept of shape memory alloys which involves light metal alloys like titanium, aluminium and magnesium alloys.	
UNIT – I	07 Hours
INTRODUCTION TO AEROSPACE MATERIALS Brief history of aerospace materials, Materials for the global aerospace industry and market, Types,Future advances in aerospace materials, Material requirements for aerospace structures and engines, Introduction to Fixed-wingaircraft structures, Helicopter structures, Space shuttle structures, satellite structures <i>(Text Book-1: Chapter 1,2,3: 1.1-1.6,2.1-2.6,3.1-3.6)</i>	
UNIT – II	08 Hours
TESTING OF AEROSPACE MATERIALS Strengthening of metal alloys: Introduction, Crystal structure of metals, Defects in crystal structures, strengthening of metal, Corrosion of aerospace metals Introduction to Tension test, Compression test, Flexure test, Hardness test, Fracture test, Drop-weight impact test, Fatigue test, Creep test, Environmental durability testing, certification of aerospace materials, Non-Destructive Testing (NDT) <i>(Text Book-1: Chapters 4&5: 4.1-4.3,5.1-5.10)</i>	
UNIT – III	08 Hours
LIGHT METAL ALLOYS Aluminum alloys for aircraft structures: Introduction, Aluminum alloy types, Heat treatment of aluminum alloys, High-temperature strength of aluminum, Introduction to Titanium alloys and their applications, Types of titanium alloy, Titaniumaluminides, Shape memory titanium alloys, Introduction to Magnesium alloys and their applications, types, Metallurgy of magnesiumalloys	

UNIT – IV	08 Hours
STEELS & SUPER ALLOYS Steels for aircraft structures: Introduction, Basic principles of steel metallurgy, Maraging steel, Medium-carbon low-alloy steel, Stainless steel, Super alloys for gas turbine engines: Introduction, Nickel-based super alloys, Iron–nickel super alloys, Cobalt super alloys, Thermal barrier coatings for jet engine alloys, advanced materials for jet engines <i>(Text Book-1: Chapters 11& 12: 11.1-11.8,12.1-12.6)</i>	
UNIT – V	08 Hours
COMPOSITE MATERIALS Applications of Composites, Fibers, Resin and other materials for composite manufacturing, Introduction to polymer matrix composites, metal matrix composites, ceramic matrix composites, and carbon fibre composites. Introduction to additive manufacturing materials. <i>(Text Book-1: Chapters 13& 14: 13.1-13.9,14.1-14.7)</i>	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Outline the requirements of materials for aerospace vehicle components.	L2& L3
2	Interpret results from the Tension test, Compression test, Flexure test, Hardness test, Fracture test, Drop-weight impact test, Fatigue test, Creep test, Environmental durability testing, certification of aerospace materials, Non-Destructive Testing.	L3 & L4
3	Describe the heat treatment of aluminum alloys, High-temperature strength of aluminum, Introduction to Titanium alloys and their applications, Types of titanium alloy, Titaniumaluminides, Shape memory titanium alloys,	L2 & L3
4	Identify the principles of steel metallurgy, Maraging steel, Medium-carbon low-alloy steel, Stainless steel, Super alloys for gas turbine engines and thermal barrier coating applications.	L2 & L3
5	Describe the Applications of Composites, Fibers, Resin and other materials for composite manufacturing.	L2

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	1										3	
C02	3	3	1				1						2	
C03	3	3			1									2
C04														2
C05		3	1											2
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)						

TEXT BOOKS:

1. Adrian P. Mouritz, "Introduction to aerospace materials", Wood head Publishing Limited, 2012, ISBN 978-1-85573-946-8
2. George E. Dieter "Mechanical Metallurgy", McGraw Hill Publications
3. William D. Callister, "Materials Science and Engineering: an Introduction", John Wiley and sons

REFERENCE BOOKS:

1. Brian Cantor, Hazel Assender and Patrick Grant, "Aerospace Materials", Institute of Physics Publishing, ISBN: 0 7503 0742
2. Sam Zhang, Dongliang Zhao "Aerospace Materials Handbook" CRC Press Taylor & Francis Group, ISBN: 978-1-4398-7330

E-Resources:

1. <https://archive.nptel.ac.in/courses/113/102/113102080/>
2. <https://sm-nitk.vlabs.ac.in/List%20of%20experiments.html>

Activity-Based Learning (Suggested Activities in Class)

1. Group discussions on new emerging materials in aircraft industry
2. Video demonstrations different materials and manufacturing process for an aircraft.

MATERIALS TESTING LABORATORY

Total Contact Hours: 24

Following are experiments to be carried out at Materials Testing Laboratory.

1. Hardness Test: The hardness test is performed to determine the resistance of a material to indentation or scratching

2. Tensile test: The tensile test is conducted to measure the mechanical properties of a material under tension.
3. Compression test: The compression test is carried out to evaluate the behaviour of a material under compressive forces
4. Impact Test: The impact test is used to assess a materials ability to absorb energy under high velocity impact.
5. Bending test: The bending test is performed to evaluate the behaviour of a material under bending loads.
6. Shear Test: The shear test is conducted to measure the strength of materials against shear forces.
7. Demonstration of Reinforcements & Matrix materials applied to aerospace industry.
8. Demonstration of Laser cutting and Engraving for space craft structures.
9. Design & Modelling of Aircraft Components using Master Cam Software.
10. Case Studies on aircraft design and manufacturing followed by site visit.

MATH FOUNDATION - IV [As per Choice Based Credit System (CBCS) scheme] SEMESTER – IV	
Course Code : 22AS2401	Credits : 03
Hours / Week : 03 Hours	Total Hours : 30 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. 9. Lecture method means it includes not only traditional lecture method, but different type of teaching methods 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 : 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					

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.

AEROSPACE MANUFACTURING

SEMESTER – IV

Course Code	: 22AS2402	Credits	: 04
Hours / Week	: 03 Hours	Total Hours	: 39 + 26 Hours
L-T-P	: 3-0-2		

Course Learning Objectives:

This course will enable students to:

1. **Analyze:** Students should develop analytical thinking and problem-solving skills specific to aerospace manufacturing. They should be able to analyze complex manufacturing challenges, propose innovative solutions, and evaluate their feasibility and impact.
2. **Get the idea:** Students should understand the ethical and sustainability challenges in aerospace manufacturing and be aware of the importance of responsible manufacturing practices.
3. **Devise:** Students should be able to read and interpret aerospace engineering principles and be able to apply them in manufacturing processes.
4. **Describe:** Students should be able to explain the key concepts and principles that govern aerospace manufacturing processes, including materials selection, production methods, quality control, and safety considerations.

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

08 Hours

CONVENTIONAL MATERIALS PROCESSING

Metal casting and forming, defects in casting, Rolling, Forging, Extrusion, Bending, Shearing, and sheet metal forming. Non-conventional machining: Basics of metal cutting, lathe, drilling and milling operations. Friction welding, explosive welding, diffusion bonding, bolted and riveted joints applied to aerospace components, CNC Mastercam.

(Text Book-1: Chapter 2 & 4)

UNIT - II

08 Hours

LASER PROCESSING OF MATERIALS

Introduction and Applications of lasers in the spacecraft industry, basic parameters, Laser Interaction with Materials, Laser processing of metals, non-metals and micromachining cutting and process characteristics, drilling, welding, bending and applications, scribing and cold cutting, performances, Surface treatment and texturing, surface alloying and cladding, selective laser melting.

(Text Book-2: Chapter 3 & 4)

UNIT – III	06 Hours
ADDITIVE MANUFACTURING Basic Principles of Additive Manufacturing and Processes, Designing for Additive Manufacturing, Multiple Materials, Hybrids, Composite Materials, current and future directions, Rapid Prototyping, and Rapid Tooling. Rapid Manufacturing; Powder-based AM processes. Printing processes, extrusion-based fused deposition modelling object, Stereolithography Micro- and nano-additives, Advantages and applications <i>(Text Book-3)</i>	
UNIT – IV	09 Hours
COMPOSITE MATERIALS PROCESSING Carbon fibres: production, structure and properties, Glass fibres: production, structure and properties, Aramid (Kevlar) fibres: production, structure and properties, Dry fabrics and Core Materials, Epoxy, Phenolic resin, Polyimide, Prepreg Manual lay-up, Automated tape lay-up (ATL), Automated fibre placement (AFP), Resin infusion, Resin transfer moulding (RTM), Vacuum bag resin infusion (VBRI), Resin film infusion (RFI), Filament winding, Pultrusion, Machining of Composite, Metal matrix composites, fibre metal laminates composites, ceramic matrix composites, carbon-carbon composites. <i>(Text Book-4: Chapter 5)</i>	
UNIT – V	08 Hours
AEROSPACE MANUFACTURING PRINCIPLE AND STANDARDS	

Component manufacturing - Raw materials; Jet engine manufacturing process - fan blade, compressor disc, compressor blades, combustion chamber, turbine disc and blades, exhaust system and final assembly; Assembly line - Fundamentals of building Aircraft, Major aircraft materials and its classification, Composite materials and its manufacturing processes, Quality control and assurance.

(Text Book-5)

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Outline of Aerospace Materials: Students will learn about the materials commonly used in aerospace manufacturing,	L2 & L3
2	Interpret in Manufacturing Techniques: Students will develop practical skills in manufacturing techniques relevant to aerospace production.	L2 & L3
3	Describe: Through practical exercises and real-world case studies, students will enhance their problem-solving and decision-making abilities in the context of aerospace manufacturing challenges.	L2 & L3
4	Identify: Ethical and Professional Conduct: Students will understand the importance of ethical behavior and professional conduct in aerospace manufacturing. They will learn about industry ethics, responsible practices, and the significance of maintaining integrity and accountability in their work.	L2 & L3
5	Describe: Students will be acquainted with quality assurance principles and practices in aerospace manufacturing. They will	L2

	learn how to perform inspections, conduct measurements, interpret specifications, and ensure compliance with industry standards and regulations.	
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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	3							2		3
C02	3	3	2	3	3							2		3
C03	3	3		3	3							1		3
C04	3	3	2	2	3							2		3
C05	3	3			2							1		3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

TEXTBOOKS:

1. Kalpakjian, S. and Schmidt, S. R., Manufacturing Processes for Engineering Materials, 5th ed., Pearson Education (2007).
2. William M. Steen · Jyotirmoy Mazumder, Laser Material Processing , 4th Edition, Springer, 2009., DOI 10.1007/978-1-84996-062-5
3. Gibson Rosen, Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing. Springer, 2009.,
4. Engineering Materials: Polymers, Ceramics and Composites A.K Bhargava Prentice Hall India
5. Standard Handbook for Aerospace Engineers, Second Edition, By Brij N. Agrawal, Max F. Platzer · 2018

REFERENCE BOOKS:

1. Abbaschian, R., Abbaschian, L., and Reed-Hill, R. E., Physical Metallurgy Principles, 4th ed., Cengage Learning (2008).

2. Krishnadas Nair, C. G. and Srinivasan, R., Materials and Fabrication Technology for Satellite and Launch Vehicle, Navbharath Enterprises (2008)

E-Resources:

3. <https://archive.nptel.ac.in/courses/101/106/101106038/>

Activity-Based Learning (Suggested Activities in Class)

3. Group discussions on advanced manufacturing processes for aircraft component
4. Video demonstrations on advanced manufacturing techniques for spacecraft and group discussions

AEROSPACE MANUFACTURING LABORATORY

Total Contact Hours: 26

The following are physical experiments to be carried out

1. Development of composite material using hand lay-up & Vacuum Bag process.
2. Development of Honeycomb composite structures.
3. Design and development of fibre metal laminates
4. Injection moulding: To prepare a plastic product using injection moulding.
5. Development of fuselage structure using Filament winding process.
6. Tension & Flexural testing of composite materials.
7. Property Evaluation of composite materials (Tension/Flexural/Deflection)
8. Non Destructive testing of Aircraft structures (Ultrasonic Flaw detector)
9. 3D modelling and Development of aircraft structures using 3D printing.
10. Design and Development of emerging aero models using additive manufacturing.

INTRODUCTION TO SPACE TECHNOLOGY

SEMESTER - IV

Course Code	: 22AS2403	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P	: 3-0-0		

Course Learning Objectives:

This course will enable students to:

1. **Analyze** the fundamentals of space technology: Students will gain a comprehensive understanding of the basic principles and concepts related to space technology,
2. **Interpret:** Students will gain an understanding of past and ongoing space exploration missions, including robotic and manned missions to planets, moons, asteroids, and other celestial bodies
3. **Identify:** Students will be introduced to the various types of **space launch systems**, such as expendable launch vehicles and reusable launch vehicles.
4. **Describe:** the diverse applications of space technology, including satellite navigation systems, weather forecasting, Earth observation, and space tourism

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	08 Hours
SPACE ENVIRONMENT Introduction to space technology, Milestones in Global Space Technologies, Atmosphere, Neutral atmosphere, Plasma, Solar Cycle, Solar Radiation, Radiation Belts, Earth's Magnetic field, Space Debris, Electro static charging, meteoroid impact, Effect of environment on Spacecraft, Aerodynamic drag, orbital mechanics.	
UNIT - II	08 Hours
SPACE PROPULSION Space Missions, objectives, Types of space travel, Principle of rocket launching, Rocket Propulsion, Staging, Solid propellant, liquid propellant and cryogenic Propulsion, Electric Propulsion, Electro-Thermal Thrusters, sounding rockets, PSLV, GSLV, Launch window, Reusable Launch Vehicle (RLV)	
UNIT - III	06 Hours
SATELLITE & SUBSYSTEMS Power Systems, Attitude Determination and Control system, Guidance and Navigation, Avionics, Telemetry, tracking and command, Communication, Structure and Mechanisms, Thermal System	
UNIT - IV	09 Hours
NANOSATELLITE, ROVERS & ASTRONAUTICS Types of spacecraft, Payload, design consideration for payloads, nano propulsion, thermal control systems, photovoltaic power generation, Solar array, Batteries, testing of satellites, simulation, concepts related to Astronautics & Space entrepreneurship	
UNIT - V	08 Hours
TESTING OF SPACE COMPONENTS AND SYSTEM Types of Tests; Test Facilities and Safeguards; Safety and Environmental Concerns; Monitoring and Control of Toxic Materials and Exhaust Gases; Instrumentation and Data Management; Reliability and Quality Control; Flight Testing. Assembly integration test, comprehensive test & test vacuum chamber and comprehensive test & test vibration facilities	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Outline the fundamental concepts and principles of space technology. They will understand the basic principles of rocketry, satellite design and operation, space exploration, and the various components and systems used in space missions.	L2 & L3
2	Interpret: Students will develop the ability to interpret and analyze data related to space technology.	L2 & L3
3	Describe: Upon completion of the course, students will be able to describe the different types of space missions and their objectives. They will be familiar with the main types of satellites, such as communication satellites, weather satellites, and scientific satellites, and will understand their specific purposes and functions	L2 & L3
4	Identify and Explain: Students will gain the skills to identify and explain the key components and systems involved in space technology. They will be able to identify the major parts of a rocket and explain their functions.	L2 & L3
5	Describe: Students will be able to describe the impact of space technology on various aspects of human life and society. They will understand how space technology is used for communication, weather forecasting, navigation, Earth observation, and scientific research..	L2

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	3							2		3
C02	3	3	2	3	3							2		3
C03	3	3		3	3							1		3
C04	3	3	2	2	3							2		3
C05	3	3			2							1		3
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)				

TEXTBOOKS:

1. Book Title: Space Technology Author: Ignacio Chechile Publication: Springer Cham Year: 2017 Edition: 1 Volume: 1 DOI: <https://doi.org/10.1007/978-3-031-34818-1>

2. Book Title: Introduction to Satellite Communication Author: Bruce R. Elbert Year: 2018
Edition: 2 Volume: 3

REFERENCE BOOKS:

3. "Space Mission Engineering: The New SMAD" by James R. Wertz and Wiley J. Larson, Volume: 4th Edition, 2 volumes, Publication: Microcosm Press
4. "Introduction to Space Dynamics" by William Tyrrell Thomson, Volume: 1st Edition, 2 volume, Publication: Dover Publications
5. "Spacecraft Systems Engineering" by Peter Fortescue, John Stark, and Graham Swinerd, Volume: 4th Edition, Publication: Wiley

E-Resources:

<https://archive.nptel.ac.in/courses/101/106/101106046/>

Activity-Based Learning (Suggested Activities in Class)

1. Group discussions on a mission, satellite building, and propulsions technology
2. Site visit/Video demonstrations on the building/launching of a spacecraft

AIRCRAFT PROPULSION			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – IV			
Course Code	: 22AS2404	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. Perform cycle analysis and determine the performance parameters of propulsion systems - turbojet, turbofan and turboprop configurations. 2. Understand the design principles of inlets, combustion chambers, and nozzles used in aircraft propulsive systems. 3. Understand the working principles of gas turbines and determine the performance characteristics of compressors and turbines.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teachers 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, note taking, annotating, and roleplaying. 3. Show Video/animation films to explain the 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.			
Course Content			
UNIT – I			12 Hours
Introduction to Propulsion Techniques: Aircraft propulsive devices – piston-prop, turbojet, turboprop, turbofan, turbo-shaft and ramjet engines; Propfans/Unducted fan engines; Engine thrust and performance parameters- Specific fuel consumption, thermal, propulsive and overall efficiencies. Factors affecting thrust and power.			

Ideal Cycle analysis of turboprop, turbojet and turbofan engine components.	
UNIT – II	07 Hours
Inlets and Nozzles: Power plant Installation types - Wing Installation, Fuselage Installation, Combined Wing and Tail Installation, Combined Fuselage and Tail Installation. The Flight Mach Number and Its Impact on Inlet Duct Geometry, Diffusers, An Ideal Diffuser, Subsonic Diffuser Performance, Subsonic Cruise Inlet, supersonic inlets. Exhaust Nozzles- Efficiencies, Thrust reversal.	
UNIT – III	06 Hours
Combustors and Afterburners: Types of the combustion system, Operational requirements, some important factors affecting combustor design, the combustion process, Combustion chamber performance, Afterburners, and Gas turbine emissions. Thrust augmentation.	
UNIT – IV	07 Hours
Compressors: Compressor types: Introduction to centrifugal compressors, Axial flow compressor- geometry- twin spools- three spools- stage analysis- velocity polygons- degree of reaction – radial equilibrium theory- performance maps.	
UNIT – V	07 Hours
Turbines: Axial flow turbines: geometry- velocity polygons- stage analysis- performance map, thermal limit of blades and vanes, blade cooling.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Determine the performance characteristics of turboprop, turbojet and turbofan engines	L2 & L3
2	Calculate pressure and temperature changes across the propulsive device, inlet, and exhaust nozzle in a gas turbine engine from the knowledge of geometry.	L2 & L3
3	Compare different types of power plant installations in an aircraft.	L2 & L3
4	Outline the requirements of combustors and compare performance of different types of combustors.	L2 & L3
5	Determine the performance characteristics of centrifugal and axial flow compressors	L3 & L4
6	Determine the performance characteristics of axial flow turbines.	L3 & 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	3
C01	3	3	1	1	2								3		
C02	3	3	1		1								2		
C03	2	1											1		
C04	2	`					2						2		
C05	3	3	2	1									2		
C06	3	3	2	1									2		

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

TEXT BOOKS:

1. R. D. Flack, "Fundamentals of Jet Propulsion with Applications", Cambridge University Press, 2005
2. H. I. H. Saravanamuttoo, G.F.C. Rogers, H. Cohen, P.V. Straznicky, and A.C. Nix and, "Gas Turbine Theory", Pearson Education Limited, 7th edition, 2017

REFERENCE BOOKS:

1. S. Farokhi, "Aircraft Propulsion", John Wiley & Sons Ltd, 2nd edition, 2014.
2. Ahmed F. El-Sayed., "Aircraft Propulsion and Gas Turbine Engines," , CRC Press Taylor & Francis Group, 2nd Edition, 2017
3. Hill, P.G. and Peterson, C.R. "Mechanics and Thermodynamics of Propulsion", Pearson India, 2nd edition, 2009.
4. J. D. Mattingly, "Elements of Gas Turbine Propulsion", McGraw Hill Publications, 1996.
5. P. M. Sforza, "Theory of Aerospace Propulsion", Elsevier-BH, 2017

E-Resources:

1. <https://nptel.ac.in/courses/112103281>
2. <https://archive.nptel.ac.in/courses/101/101/101101002/>

LOW SPEED AERODYNAMICS

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

SEMESTER – IV

Course Code	: 22AS2405	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 44 Hours
L-T-P-S	: 3-0-2-0		

Course Learning Objectives:

This Course will enable students to:

1. **Understand** the applications of basic laws of conservation laws of mass, momentum and energy as applied to aerodynamics
2. **Use of transformations** to solve basic flows and their superposition leading to inviscid theories of flow past objects, concepts of Vorticity, Irrotationality and Potential Flows
3. **Explain** the theory of lift generation due to circulation around airfoils
4. **Understand** viscous flows, boundary layer separation

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

08 Hours

INTRODUCTION:

(Selected Chapters from Text Books 1 to 4)

Properties of Fluids, Basic Laws, Integral and Differential Analysis, Kinematics of Fluid Flow, Viscous flows, Boundary layer transition, Separation, Rotational and Irrotational Flows, Velocity Potential and Stream Function, Two-dimensional Source and Sink, Vortex, Doublet,

Combination of Simple Flows, Flow Past a Half-Body, Circular Cylinder without and with Circulation, Magnus effect, Drag of Bodies, Turbulence, Flow through Pipes	
UNIT – II	08 Hours
TRANSFORMATIONS <i>(Text Books 2-3)</i> Introduction to Conformal transformation, Complex functions, Kutta Joukowski transformation, Kutta Condition, Airfoil characteristics, Aerodynamic forces and moment coefficients, Vortex theory, Laws of vortex motion, Helmholtz theorems, Forced and Free vortex, Circulation, Biot-Savart's law, Circular and Rectilinear vortex, Vortex line	
UNIT – III	06 Hours
AIRFOIL THEORY <i>(Text Book - 3)</i> Introduction, General Thin Aerofoil Theory, Thin Symmetrical Flat Plate Aerofoil, Circular Arc Aerofoil, Lift, Pitching Moment, Center of Pressure, Thin Aerofoil, Flapped Aerofoil, High-lift devices, Panel Methods, Source panel, vortex panel methods and application to flow past a circular cylinder	
UNIT – IV	10 Hours
FINITE WING THEORY <i>(Text Book - 3)</i> Introduction, Spanwise loading and Trailing Vorticity, Downwash, Characteristics of elliptic distribution, Drag due to Downwash, Downwash and Vortex drag for modified elliptic loading, Condition for Vortex Drag Minimum, Lancaster – Prandtl Lifting Line theory, Induced Drag, Effect of downwash on Incidence, Integral Equation for Circulation, Lift curve slope and effect of Aspect Ratio with Incidence, Rectangular Airfoil, Lifting Surface Theory, Velocity Induced by a Lifting Line Element, Munk's theorem, Small Aspect Ratio, Vortex lattice method for wings, Lift, drag and moment characteristics of complete airplane. Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane.	
UNIT – V	08 Hours
INTRODUCTION TO VISCOUS FLOWS <i>(Text Books: 3-4)</i> Boundary layer and boundary layer thickness, Displacement thickness, Momentum thickness, Energy thickness, Shape parameter, Boundary layer equations for a steady, two dimensional incompressible flow, Boundary layer growth over a flat plate, Critical Reynolds number, Blasius solution, Natural laminar flow airfoils, Laminar flow controlled airfoils, Basics of turbulent flow.	
<u>Course Outcomes:</u> At the end of the course the student will be able to:	
1. Use the theory of elementary flows to analyze flow over different geometries.	

2. **Interpret** the lift and drag generation due to flow over surfaces
3. **Apply** the transformations from the physical plane to complex plane for analysis of fluid flows
4. **Analyze** ideal and real aerodynamic characteristics of flow over wing surfaces at low speeds

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											1		
C02	3	3											1		
C03	3	3											1		
C04	3	3											1		
C05	3	3											1		
3: Substantial (High)					2: Moderate (Medium)					1: Poor (Low)					

TEXT BOOKS:

1. Houghton, E.L., and Caruthers, N.B., “Aerodynamics for Engineering students”, Edward Arnold Publishers Ltd., London, 1989
2. R K Bansal, A Textbook of Fluid Mechanics and Fluid Machines, Revised 9th Edition, Lakshmi Publications Pvt Ltd., New Delhi, 2010
3. E Rathakrishnan, Theoretical Aerodynamics, Published by John Wiley and Sons, Singapore, 2013
4. Anderson, J.D., “Fundamentals of Aerodynamics”, McGraw Hill Book Co., 1999

REFERENCE BOOKS:

1. Horowitz E., Sahni S., Rajasekaran S, “Computer Algorithms”, Galgotia Publications, 2001.
2. R.C.T. Lee, S.S. Tseng, R.C. Chang & Y.T.Tsai, “Introduction to the Design and Analysis of Algorithms A Strategic Approach”, Tata McGraw Hill, 2005.

E-Resources:

1. <https://youtu.be/KqfYobOYRTc>
2. <https://youtu.be/gLPJAjyiUxA>
3. <https://youtu.be/4qppw7dO7kM>
4. <https://youtu.be/AarN5AmlhjY>

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving and puzzles using group discussion, e.g., Sports aerodynamics, Automotive and Industrial aerodynamics

INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – IV	
Course Code : 22AS2406	Credits : 03
Hours / Week : 04 Hours	Total Hours : 26 + 26 Hours
L-T-P : 2-0-2	
Course Learning Objectives: This course will enable students to: 1. Explain the basic governing equations and understand the properties of CFD. 2. Understand discretization techniques and solving methods for improving accuracy. 3. Inculcate the knowledge required to solve physical problems using simulation software.	
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	03 Hours
Introduction: Advantages and applications of CFD, CFD solution procedure – Pre-process, CFD solver, Post process, testing.	
UNIT – II	06 Hours
Governing Equations: Continuity, momentum and Energy equations, equations for turbulent flows, classification of PDEs, generic form of governing equations for CFD, physical boundary conditions	

UNIT – III	04 Hours
Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation, moving mesh.	
UNIT – IV	08 Hours
CFD Techniques: Discretization of governing equations – FDM, FVM, FEM, Numerical solution, Explicit and Implicit schemes, pressure velocity coupling.	
UNIT – V	05 Hours
CFD Solution Analysis: Consistency, stability, convergence, accuracy, efficiency. Guidelines for boundary conditions, turbulence modelling and Validation.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Outline the CFD solution procedure.	L2 & L3
2	Classify PDEs and derive governing equations- continuity, momentum and energy.	L2 & L3
3	Choose 2D grids for a particular fluid flow problem.	L2 & L3
4	Apply finite difference method and finite volume methods for the discretization of the fluid flow problems.	L2 & L3
5	Use of suitable numerical methods for solving the governing equations in the discretized domain by understanding stability and convergence.	L2 & L3
6	Solve fluid flow and heat transfer problems using CFD software	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	3
C01	3				2								2		
C02	3				2								1		
C03	2	2			2							1	1	1	
C04	3	3	2		2									1	
C05	3	2	2		3										
C06	3	2	2	2	3				2	2		2	2	2	
3: Substantial (High)				2: Moderate (Medium)						1: Poor (Low)					

TEXT BOOKS:

1. Jiyuan Tu, Guan-Heng Yeoh, Chaoqun Liu, "Computational Fluid Dynamics A Practical Approach", 3rd Edition, Butterworth-Heinemann, 2018.
2. Atul Sharma, "Introduction to Computational Fluid Dynamics Development, Application and Analysis", ANE Books Pvt. Ltd, Springer Nature Switzerland AG ,2022.

REFERENCE BOOKS:

1. H.K. Versteeg and W. Malalasekera , "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", , Second Edition, Pearson Education Limited, 2007.
2. Anderson J.D. Computational Fluid Dynamics, Mc-Graw Hills (1995)
3. J.C. Tannehill, D.A. Anderson, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis

E-Resources:

1. <https://nptel.ac.in/courses/112105045>

INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS - LAB**Total Contact Hours: 26**

Following simulations to be done using CFD software:

1. Discretization and numerical solution of 1D steady-state heat transfer through the slab.
2. Numerical solution of a potential flow problem.
3. Solution convergence monitoring, flow visualization and post-processing techniques and tools.
4. Introduction to CFD software and setup test case-1 for laminar flow – internal and external.
5. Mesh generation for test case-1 using the inbuilt tool.
6. Grid independence test, results reporting and visualization.
7. CFD study of laminar and turbulent flow around a cylinder. Selection of different turbulent models.
8. CFD study of laminar flow past a backwards-facing step.
9. CFD study of natural convection in a square cavity.
10. CFD study of flow around airfoils.
11. CFD study of compressible flow around cylinders and cones.
12. CFD study of compressible flow around blunt bodies.
13. CFD study of flow behind a rotating cylinder.
