



SCHOOL OF ENGINEERING

Department of

Artificial Intelligence and Robotics

SCHEME AND SYLLABUS

B.Tech. PROGRAMME– 2023-27 BATCH

Academic Year 2023-27

**Devarakaggalahalli, Harohalli,
Kanakapura Main Road,
Bangalore South– 562112**



Definitions / Descriptions

Definition of Credit

1 Hour lecture (L) Per Week	01 Credit
1 Hour Tutorial (T) Per Week	01 Credit
1 Hour Practical (P) Per Week	0.5 Credit
1 Hour Project (J) Per Week	0.5 Credit

Course code and Definition

BSC	Basic science courses
ESC	Engineering Science Courses
HSMC	Humanities and Social Sciences including Management Courses
IPCC	Integrated Professional Core Course
PCC	Professional Core Course
PEC	Professional Elective Courses
OEC	Open Elective Courses
SEC	Skill Enhancement Courses

UHV	Universal Human Value Course
PROJ	Project Work
INT	Internship

Implementation of National Education Policy (NEP) 2020 for the B. Tech students of Batch 2023-2027

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

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

SCHEME 2023 – 2027 Batch



**DAYANANDA SAGAR
UNIVERSITY**



**SCHOOL OF
ENGINEERING**

III-SEMESTER													
S.N	Program Code	Course Code	Course Title	Teaching Department	Teaching Hours /Week				Examination				Credit
					Lecture	Tutorial	Practical	Project	Contact Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	141	23RA2301	PROBABILITY AND STATISTICS	MAT	3	0	0	0	4	60	40	100	4
2	141	23RA2302	DATA STRUCTURES	AIR	2	0	2	0	4	60	40	100	4
3	141	23RA2303	PRINCIPLES OF ARTIFICIAL INTELLIGENCE	AIR	3	1	0	0	3	60	40	100	4
4	141	23RA2304	FOUNDATIONS OF MACHINE LEARNING AND NEURAL NETWORKS	AIR	3	0	2	0	5	60	40	100	4
5	141	23RA2305	FUNDAMENTALS OF ROBOT MECHANICS	AIR	3	0	2	0	5	60	40	100	4
6	141	23RA23XX	LIBERAL STUDIES - I	ANY DEPT.	1	0	0	0	1	50	--	50	1
7	141	23RA23XX	SKILL ENHANCEMENTCOURSE - I	AIR	1	0	2	0	3	100	--	100	2
8	141	23RA2306	COGNITIVE AND TECHNICAL SKILLS - III	ANY DEPT.	0	0	4	0	4	100	--	100	2
		TOTAL			16	0	12	0	28	550	200	750	23

Skill Enhancement Course – I

S.N	Course Code	Course Name
1	23RA2307	PLC PROGRAMMING FOR AUTOMATED SYSTEMS
2	23RA2308	HYDRAULICS AND PNEUMATICS FOR ROBOTICS



	IV-SEMESTER												
S.N	Program Code	Course Code	Course Title	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Contact Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	141	23RA2401	TRANSFORMS AND NUMERICAL TECHNIQUES	MAT	3	0	0	0	3	60	40	100	3
2	141	23RA2402	MECHATRONICS AND SMART MANUFACTURING	AIR	3	0	0	0	3	60	40	100	3
3	141	23RA2403	KINEMATICS AND DYNAMICS FOR ROBOTICS	AIR	3	0	2	2	5	60	40	100	4
4	141	23RA2404	COMPUTER ORGANIZATION AND ARCHITECTURE	AIR	3	1	0	0	4	60	40	100	4
5	141	23RA2405	ADVANCED DEEP LEARNING	AIR	3	0	2	0	5	60	40	100	4
6	141	23RA24XX	SKILL ENHANCEMENTCOURSE - II	AIR	1	0	2	0	3	100	--	100	2
7	141	23RA2406	COGNITIVE AND TECHNICAL SKILLS - IV	CST	0	0	4	0	4	100	--	100	2
			TOTAL		16	1	10	2	27	500	200	700	22

Skill Enhancement Course - II		
S.N	Course Code	Course Name
1	23RA2407	PROTOTYPING WITH 3 D PRINTING
2	23RA2408	INTERNET OF THINGS



V-SEMESTER													
S.N	Program Code	Course Code	Course Title	Teaching Department	Teaching Hours /Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Contact Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J	Contact Hours	CIE Marks	SEE Marks	Total Marks	
1	141	23RA3501	MOBILE ROBOTICS	AIR	3	1	0	0	4	60	40	100	4
2	141	23RA3502	REINFORCEMENT LEARNING	AIR	3	0	2	0	5	60	40	100	4
3	141	23RA3503	CONTROL SYSTEMS FOR ROBOTICS	AIR	3	0	0	0	3	60	40	100	3
4	141	23RA3504	ROBOT OPERATING SYSTEMS	AIR	3	0	0	2	5	60	40	100	4
5	141	23RA3505	ROBOTIC VISION	AIR	3	0	2	0	5	60	40	100	4
6	141	23RA35XX	PROFESSIONAL ELECTIVE - I	AIR	2	0	0	0	2	60	40	100	2
7	141	23RA3506	COGNITIVE AND TECHNICAL SKILLS - V	ALL	0	0	0	0	0	50	--	50	P/F
			TOTAL		17	1	8	2	23	410	240	650	21

Professional Elective Course - I		
S.N	Course Code	Course Name
1	23RA3507	THERMAL FLUIDS AND ELECTRONICS COOLING
2	23RA3508	PATTERN RECOGNITION
3	23RA3509	ADVANCED AI TECHNIQUES FOR ROBOTICS
4	23RA3510	HEALTHCARE ROBOTICS



VI-SEMESTER													
S.N	Program Code	Course Code	Course Title	Teaching Department	Teaching Hours /Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Contact Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J	Contact Hours	CIE Marks	SEE Marks	Total Marks	
1	141	23RA3601	GENERATIVE AI	AIR	3	0	2	0	5	60	40	100	4
2	141	23RA3602	INNOVATION AND ENTREPRENEURSHIP	AIR	2	0	0	0	2	60	40	100	2
3	141	23RA3603	HUMANOID ROBOTS	AIR	3	0	2	0	5	60	40	100	4
4	141	23OE36XX	OPEN ELECTIVE - I	AIR	3	0	0	0	3	60	40	100	3
5	141	23RA36XX	PROFESSIONAL ELECTIVE - II	AIR	3	0	0	0	3	60	40	100	3
6	141	23RA36XX	PROFESSIONAL ELECTIVE - III	AIR	3	0	0	0	3	60	40	100	3
7	141	23RA3604	COGNITIVE AND TECHNICAL SKILLS - VI	CTS	0	0	0	0	0	50	--	50	P/F
TOTAL					17	0	4	0	21	410	240	650	19

NOTE:

Internship: All the students admitted to III year shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A university examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements

Open Electives-I		
S.N	Course Code	Course Name
1	23RA3605	AGILE METHODOLOGY FOR PROJECT DEVELOPMENT
2	23RA3606	PRODUCT ENGINEERING & ENTREPRENEURSHIP

Professional Elective Course – II		
<u>S.N</u>	Course Code	Course Name
1	23RA3607	ROBOTIC MANIPULATION AND GRASPING
2	23RA3608	HEURISTIC ALGORITHMS FOR GLOBAL OPTIMIZATION
3	23RA3609	COGNITIVE ARCHITECTURES
4	23RA3610	AGRICULTURAL ROBOTICS

Professional Elective Course – III		
<u>S.N</u>	Course Code	Course Name
1	23RA3611	MULTI-ROBOT SYSTEMS
2	23RA3612	BLOCKCHAIN AND SECURITY IN AI
3	23RA3613	EXPERT SYSTEMS AND APPLICATIONS
4	23RA3614	ROBOTIC LOGISTICS AND WAREHOUSING



	VII-SEMESTER												
S.N	Program Code	Course Code	Course Title	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Contact Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	141	23RA4701	FUNDAMENTALS OF ECONOMICS	AIR	3	1	0	0	3	60	40	100	4
2	141	23RA4702	COGNITIVE SYSTEMS IN AI AND ROBOTICS	AIR	3	0	0	2	5	60	40	100	4
3	141	23RA47XX	OPEN ELECTIVE - II	AIR	3	0	0	0	3	60	40	100	3
4	141	23RA47XX	PROFESSIONAL ELECTIVE - IV	AIR	3	0	0	0	3	60	40	100	3
5	141	23RA47XX	PROFESSIONAL ELECTIVE - V	AIR	3	0	0	0	3	60	40	100	3
6	141	23RA4703	CAPSTONE PROJECT PHASE - I	AIR	0	0	0	6	6	100	--	100	3
		TOTAL			15	0	0	8	23	400	200	600	20

Open Electives-II		
S.N	Course Code	Course Name
1	23RA4704	LEAN STARTUP METHODOLOGY
2	23RA4705	BUSINESS ANALYTICS
3	23RA4706	DESIGN THINKING

Professional Elective Course – IV		
<u>S.N</u>	Course Code	Course Name
1	23RA4707	INDUSTRIAL ROBOTICS
2	23RA4708	MULTILINGUAL SPEECH AND LANGUAGE PROCESSING
3	23RA4709	EMBEDDED SYSTEMS
4	23RA4710	AUTONOMOUS VEHICLES

Open Electives-II		
<u>S.N</u>	Course Code	Course Name
1	23RA4711	SOFT ROBOTICS
2	23RA4712	FUNDAMENTALS OF VIRTUAL REALITY AND APP DEVELOPMENT
3	23RA4713	INTRODUCTION TO QUANTUM COMPUTING
4	23RA4714	ROBOTICS IN MANUFACTURING



VIII 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	141	23RA4801	CAPSTONE PROJECT PHASE – II	AIR	0	0	0	24	24	60	40	100	12
2	141	23RA4802	RESEARCH INTERNSHIP/ INDUSTRY INTERNSHIP	AIR	0	0	6	0	6	60	40	100	03
			Total		00	00	06	24	30	120	80	200	15

NOTE 1: Internship

Completed during the intervening vacations of VI and VII semesters and /or VII and VIII semesters or VIII semesters

NOTE: Total Credits (I-Sem to VIII Sem) = 160 credits.

SEMESTER	CREDITS
I	20
II	20
III	23
IV	22
V	21
VI	19
VII	20
VIII	15
TOTAL CREDITS	160



S.N	Domain-wise Clusters		PROFESSIONAL ELECTIVE COURSES				
			PEC-I	PEC-II	PEC-III	PEC-IV	PEC-V
			5 th Semester	6 th Semester		7 th Semester	
1	Domain-1	Course Code					
		ROBOTICS AND AUTOMATION	THERMAL FLUIDS AND ELECTRONICS COOLING	ROBOTIC MANIPULATION AND GRASPING	MULTI-ROBOT SYSTEMS	INDUSTRIAL ROBOTICS	SOFT ROBOTICS
2	Domain-2	Course Code					
		ADVANCED ANALYTICS AND INTELLIGENCE SYSTEMS	PATTERN RECOGNITION	HEURISTIC ALGORITHMS FOR GLOBAL OPTIMIZATION	BLOCKCHAIN AND SECURITY IN AI	MULTILINGUAL SPEECH AND LANGUAGE PROCESSING	FUNDAMENTALS OF VIRTUAL REALITY AND APP DEVELOPMENT
3	Domain-3	Course Code					
		ARTIFICIAL INTELLIGENCE AND COGNITIVE COMPUTING	ADVANCED AI TECHNIQUES FOR ROBOTICS	COGNITIVE ARCHITECTURES	EXPERT SYSTEMS AND APPLICATIONS	EMBEDDED SYSTEMS	INTRODUCTION TO QUANTUM COMPUTING
4	Domain-4	Course Code					
		APPLICATIONS OF ROBOTICS	HEALTHCARE ROBOTICS	AGRICULTURAL ROBOTICS	ROBOTIC LOGISTICS AND WAREHOUSING	AUTONOMOUS VEHICLES	ROBOTICS IN MANUFACTURING
5	Domain-5	Course Code					
		MooC	MooC	MooC	MooC	MooC	MooC

How do Specialized Emerging Domain Verticals help Students?

- Specialized domain vertical courses are **customized** based on the current industry trends and future career scope.

It enables both faculty and students the **flexibility** in determining key areas of study that they need to focus on.

- Specialization in domain specific provides students with **greater access to resources**, professors, and opportunities than a single program.
- Hiring people or managers of reputed companies would love to see students with some relevant **practical experience** in their desired field. Having good knowledge of a domain lets students hit the ground running.
- Students can take advantage of the strengths in the specialized courses to **jump-start their careers**.
- A degree with a great specialization program is comparatively **less expensive** than taking up two separate programs separately.

III-Semester Syllabus

PROBABILITY AND STATISTICS [As per Choice Based Credit System (CBCS) scheme] SEMESTER – III			
Subject Code	: 23RA2301	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This Course will enable students to: 1. Apply statistical principles and probability concepts to solve complex problems in real-world scenarios involving uncertainty and randomness. 2. Evaluate and select appropriate probability distributions and statistical techniques to analyze and interpret data accurately in various applications. 3. Justify the use of estimation methods and hypothesis testing techniques for drawing meaningful inferences about population parameters. 4. Analyze and interpret sample test results for different statistical relationships, such as means, variances, correlation coefficients, regression coefficients, goodness of fit, and independence, to make informed decisions. 5. Identify sample tests using appropriate statistical procedures to investigate the significance of observed data and communicate findings effectively.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different type of teaching methods may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I			09 Hours
Probability Definitions of Probability, Addition Theorem, Conditional Probability, Multiplication Theorem, Bayes' Theorem of Probability			
UNIT – II			09 Hours
Random Variables and their Properties and Probability Distributions 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	06 Hours
Estimation and testing of hypothesis Sample, Populations, Statistic, Parameter, Sampling Distribution, Standard Error, Un-Biasedness, Efficiency, Maximum Likelihood Estimator, Notion & Interval Estimation.	
UNIT – IV	07 Hours
Sample Tests-1 Large Sample Tests Based on Normal Distribution, Small Sample Tests: Testing Equality of Means, Testing Equality of Variances, Test of Correlation Coefficient	
UNIT – V	08 Hours
Sample Tests-2 Test for Regression Coefficient; Coefficient of Association, 2 – Test for Goodness of Fit, Test for Independence.	

Course Outcome

Course Outcomes (COs)	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

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	2	2	-	2	2	1	1	1	1	1	2	2	2
CO-2	3	3	2	2	-	1	2	-	-	1	2	1	2	3	3
CO-3	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3
CO-4	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3
CO-5	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

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

REFERENCE BOOKS:

1. Probability, Statistics and Random Processes T. Veerarajan Tata McGraw – Hill
2. 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 that 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

- 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.
- Data: The data consists of the number of customer arrivals recorded at the coffee shop during each 15-minute interval for the past month.
- 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	0
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

- 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.
- 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.

- 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

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

DATA STRUCTURES [As per Choice Based Credit System (CBCS) scheme] (Lab Integrated Core Course)			
SEMESTER – III			
Course Code	: 23RA2302	Credits	: 04
Hours / Week	: 03	Total Hours	: 36+26
L-T-P-J	: 2-0-2-0	CIE+SEE	: 60+40 Marks
Prerequisites: 1. Proficiency in a C programming language.			
Course Objectives: This Course will enable students to: 1. Understand the basic approaches for analyzing and designing data structures. 2. Introduce dynamic memory allocation and C language concepts required for building data structures 3. Develop essential skills to construct data structures to store and retrieve data quickly and efficiently. 4. Utilize different data structures that support different sets of operations which are suitable for various applications. 5. Explore & implement how to insert, delete, search and modify data in any data structure- Stack, Queues, Lists, Trees. 6. Develop applications using the available data structure as part of the course for mini-project.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • 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
Introduction to Data Structure Classification, C Structure and Union, Array Definition, Representation, Operations (Insertion, Deletion, Search and Traversal), Two/Multidimensional Arrays, sparse matrix, C Pointers. TB1: 1.1, 2.2, 2.5; TB2: 1.1, 1.2, 1.3.1-1.3.4; RB1: 5.1 – 5.12, 6.4			
UNIT – II			08 Hours
INTRODUCTION TO ADT Stack: Definition, Array Representation of Stack, Operations on Stacks. Applications of Stack: Expression evaluation, Conversion of Infix to Postfix, Infix to Prefix Recursion, Tower of Hanoi. Queue: Definition, Representation of Queues, Operations of Queues, Circular Queue. Applications of Queue: Job Scheduling, A Maze Problem TB1: 3.1, 3.2, 3.3, 3.4, 3.5; TB2: 2.1, 2.2, 2.3, 3.2, 3.3			

UNIT – III		07 Hours
DYNAMIC DATA STRUCTURES		
Linked List: Types, Representation of Linked Lists in Memory. Traversing, Searching, Insertion & Deletion from Linked List. Circular List, Doubly Linked List, Operations on Doubly Linked List (Insertion, Deletion, Traversal). Applications: Stack & Queue Implementation using Linked Lists. Case Study: Josephus problem. TB2: 4.2,4.3,4.5		
UNIT – IV		08 Hours
TREES		
Basic Terminology, Binary Trees and their representation, Complete Binary Trees, Binary Search Trees, Threaded Binary Trees, Operations on Binary Trees (Insertion, Deletion, Search & Traversal). TB1: 5.1,5.2,5.3,5.5,5.7. Applications: Expression Evaluation. Case Study: Game Tree TB2: 5.5.3,5.5.4,5.6.		
UNIT – V		05 Hours
Efficient Binary Search Trees		
Optimal Binary Search Trees, AVL Trees, Red Black Trees, Splay Trees. Case Study: B Trees TB1: 10.1,10.2,10.3,10.4, 11.2		

Course Outcome

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Demonstrate the key C programming concepts such as pointers, structures, unions and arrays data structures to perform operations such as insertion, deletion, searching, sorting, and traversing.	L2 & L3
2	Utilize the fundamental concepts of stacks and queues to solve the standard applications like tower of Hanoi, conversion and evaluation of expressions, job scheduling and maze.	L2
3	Implement Singly Linked List, Doubly Linked List, Circular Linked Lists, stacks and queues using linked list.	L2
4	Develop critical thinking and problem-solving skills by designing and implementing efficient algorithms for Non-linear tree data structure and perform insertion, deletion, search and traversal operations on it.	L3
5	Apply advanced techniques, such as balancing algorithms for AVL trees, Splay trees and Red-Black trees to maintain the balance and efficiency of binary trees.	L2 & L3

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	3	2	-	1	2	-	-	1	2	2	2	3	2
CO-2	3	3	3	2	-	1	2	-	1	1	2	2	2	3	2
CO-3	3	3	3	2	-	1	2	-	1	1	2	2	2	3	2
CO-4	3	3	3	3	-	1	2	-	-	1	2	2	2	3	3
CO-5	3	3	3	3	-	1	2	-	-	1	2	2	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Ellis Horowitz, Susan Anderson-Freed, and Sartaj Sahni, "Fundamentals of Data structures in C", 2nd Edition, Orient Longman, 2008.
2. A.M. Tannenbaum, Y Langsam, M J Augentien, "Data Structures using C", 1st Edition, Pearson, 2019.

REFERENCE BOOKS:

1. Brian. W. Kernighan, Dennis. M. Ritchie, "The C Programming Language", 2nd Edition, Prentice- Hall, 1988.
2. Gilbert & Forouzan, "Data Structures: A Pseudo-code approach with C", 2nd Edition, Cengage Learning, 2014.
3. Jean-Paul Tremblay & Paul G. Sorenson, "An Introduction to Data Structures with Applications", 2nd Edition, McGraw Hill, 2013.
4. R.L. Kruse, B.P. Learly, C.L. Tondo, "Data Structure and Program design in C", 5th Edition, PHI, 2009.

E-Resources:

1. <https://nptel.ac.in/courses/106102064>
2. <https://www.coursera.org/learn/data-structures?specialization=data-structures-algorithms>
3. <https://www.udemy.com/topic/data-structures/free/>
4. <https://www.mygreatlearning.com/academy/learn-for-free/courses/data-structures>
5. <https://cse01-iiith.vlabs.ac.in/>
6. <https://kremlin.cc/k&r.pdf>

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving using group discussion.
2. Role play E.g., Stack, Queue, etc.,
3. Demonstration of solution to a problem through programming.
4. Flip class activity E.g., arrays, pointers, dynamic memory allocation, etc.

LABORATORY EXPERIMENTS

Total Contact Hours: 26

Following are experiments to be carried out using either C programming language

1. To Implement C programs with concepts of pointers, structures.
2. To implement multidimensional array Matrix Multiplication.
3. To search elements in data structure with different search methods.
4. To implement stack, queue and their variations using arrays.
5. To implement stack, queue and their variations using singly linked lists
6. To implement conversion & evaluation of expression using stacks.
7. To Implement doubly circular Linked Lists and variations and use them to store data and perform operations on it.
8. To Implement Addition/multiplication of 2 polynomial using linked lists
9. To implement binary tree traversal techniques.

OPEN-ENDED EXPERIMENTS

1. A man in an automobile search for another man who is located at some point of a certain road. He starts at a given point and knows in advance the probability that the second man is at any given point of the road. Since the man being sought might be in either direction from the starting point, the searcher will, in general, must turn around many times before finding his target. How does he search to minimize the expected distance travelled? When can this minimum expectation be achieved?
2. The computing resources of a cloud are pooled and allocated according to customer demand. This has led to increased use of energy on the part of the service providers due to the need to maintain the computing infrastructure. What data structure will you use for allocating resources which addresses the issue of energy saving? Why? Design the solution.
3. Mini-Project on applying suitable data structure to a given real-world problem.

PRINCIPLES OF ARTIFICIAL INTELLIGENCE

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

SEMESTER – III

Subject Code	: 23RA2303	Credits	: 04
Hours / Week	: 04	Total Hours	: 52
L-T-P-J	: 3-1-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This Course will enable students to: 1. Understand the foundational principles of artificial intelligence, including the history, philosophy, and various types of intelligent agents. 2. Develop proficiency in logical reasoning and knowledge representation to enable the creation of systems that can reason and make decisions autonomously. 3. Master classical and advanced planning techniques, learning to formulate problems and devise strategies for dynamic and uncertain environments. 4. Acquire skills in natural language processing, focusing on language understanding, parsing, and dialogue system creation. 5. Explore the ethical and philosophical challenges in AI, analysing the impact of AI technologies on society and individual privacy.			
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 analyze 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
Foundations of Artificial Intelligence: Introduction to AI: Definitions, history, and philosophy, Intelligent Agents: Concepts of agents, environments, and the structure of agents, Problem Solving and Search: Problem representation, uninformed search strategies, and the concept of optimality.			
UNIT – II			08 Hours
Logical Agents and Knowledge Representation: Logical Agents: Propositional and first-order logic, building agents that reason logically. Knowledge Representation: Semantic networks, frames, and ontologies, emphasizing how knowledge can be represented symbolically. Automated Reasoning: Techniques for automated deduction, inference rules, and the resolution method.			
UNIT – III			08 Hours
Planning and Decision Making: Classical Planning: Problem formulation, solution strategies, and planning graphs. Beyond Classical Planning: Handling dynamic environments, planning under uncertainty, and partial observability. Decision Making: Utility theory, decision networks, and game theory for modeling multi-agent interactions.			

UNIT – IV	09 Hours
Natural Language Processing and Communication: Language Models: Syntax, semantics, and parsing. Natural Language Understanding: From textual input to logical representation, including the challenges of ambiguity and context. Dialogue Systems: Structure, function, and challenges of creating systems that can engage in human-like dialogue.	
UNIT – V	06 Hours
Ethical and Philosophical Aspects of AI: Ethical AI: Theories and practices in developing AI that aligns with ethical standards. Philosophy of AI: Key philosophical questions surrounding AI, including consciousness, intelligence, and the potential future of AI-human interaction. Social Implications of AI: Discussion on privacy, surveillance, and the broader impacts of AI on society.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply knowledge of intelligent agents and problem-solving strategies to design and evaluate AI systems that can operate effectively within defined environments.	L2 & L3
2	Synthesize concepts from logical reasoning and knowledge representation to develop AI applications that can reason, learn, and adapt to new information autonomously.	L2 & L3
3	Demonstrate the ability to formulate and solve planning problems using classical and contemporary AI planning techniques, especially in scenarios with incomplete or uncertain information.	L2 & L3
4	Construct natural language processing systems that effectively parse, interpret, and generate human language, demonstrating an understanding of the complexities involved in language and communication.	L2 & L3
5	Evaluate the ethical implications of AI systems, proposing solutions that mitigate risks and enhance societal benefits, thereby ensuring that AI development aligns with ethical standards and human values.	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
CO-1	3	3	2	2	-	2	2	1	1	1	1	1	2	2	2
CO-2	3	3	2	2	-	1	2	-	-	1	2	1	2	3	3
CO-3	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3
CO-4	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3
CO-5	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

Textbooks:

1. "Artificial Intelligence: Foundations of Computational Agents, 2nd Edition" by David L. Poole and Alan K. Mackworth, published by Cambridge University Press.
2. "Artificial Intelligence: A Modern Approach, 4th Edition" by Stuart Russell and Peter Norvig, published by Pearson.

References:

1. "Philosophy of Artificial Intelligence: A Critique of the Mechanistic Theory of Mind" by Michael R. LaChat, published by Routledge.
2. "The Ethics of Artificial Intelligence" edited by S. Matthew Liao, published by Oxford University Press.

FOUNDATIONS OF MACHINE LEARNING AND NEURAL NETWORKS

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

SEMESTER – III

Subject Code	: 23RA2304	Credits	: 04
Hours / Week	: 05	Total Hours	: 39+26 = 65
L-T-P-J	: 3-0-2-0	CIE+SEE	: 60+40 Marks
Course Objectives: This Course will enable students to: 1. Understand core concepts of machine learning, including different types of learning such as supervised, unsupervised, and their applications. 2. Develop skills in preprocessing data for machine learning, emphasizing the importance of data quality, normalization, and transformation. 3. Gain proficiency in building and evaluating predictive models using techniques like regression, classification, and clustering. 4. Learn the fundamentals of neural networks, including architecture, activation functions, and the basics of training networks through backpropagation. 5. Implement practical machine learning workflows, mastering the process of feature engineering, model selection, and deployment in real-world scenarios.			
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 outcome • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
UNIT – I			08 Hours
Introduction to Machine Learning Overview of Machine Learning: Definitions and types of machine learning (supervised, unsupervised, reinforcement). Machine Learning Systems: Components of ML systems, challenges in machine learning, applications, and case studies. Data Preprocessing: Data collection, cleaning, normalization, and transformation techniques.			

UNIT – II	08 Hours
Supervised Learning Techniques Regression Analysis: Linear regression, polynomial regression, and model evaluation metrics. Classification: Logistic regression, k-nearest neighbors, support vector machines, and decision trees. Model Evaluation: Cross-validation, overfitting and underfitting, bias-variance tradeoff.	
UNIT – III	06 Hours
Unsupervised Learning and Dimensionality Reduction Clustering: K-means, hierarchical clustering, DBSCAN, and applications in segmentation. Dimensionality Reduction: Principal Component Analysis (PCA), Singular Value Decomposition (SVD), t-SNE. Association Rule Learning: Apriori algorithm, market basket analysis.	
UNIT – IV	09 Hours
Introduction to Neural Networks Perceptron's: The basic structure of artificial neurons, perceptron learning algorithm. Feedforward Neural Networks: Network architectures, activation functions, forward and backpropagation. Training Neural Networks: Loss functions, gradient descent, backpropagation details.	
UNIT – V	08 Hours
Practical Aspects of Machine Learning Feature Engineering: Techniques for feature selection and feature engineering to improve model performance. Ensemble Methods: Bagging, boosting, random forests, and their advantages in model accuracy improvement. Machine Learning Pipelines: Building end-to-end machine learning pipelines, from data ingestion to model deployment.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Demonstrate the ability to implement and fine-tune machine learning models, such as linear regression, SVM, and decision trees, to solve real-world problems.	L2 & L3
2	Apply clustering and principal component analysis techniques to effectively manage and interpret large datasets with complex structures.	L2 & L3
3	Construct and train neural networks, understanding the practical aspects of architecture selection, activation functions, and learning algorithms.	L2 & L3
4	Develop comprehensive machine learning pipelines, incorporating all stages from data preprocessing and feature engineering to model training and validation.	L2 & L3
5	Evaluate and enhance the robustness of machine learning models using ensemble techniques and advanced validation methods to ensure high performance and reliability.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	3	2	-	2	2	2	2	2	2	3	3	3	3
CO-2	3	3	3	2	-	2	2	2	2	2	2	3	3	3	3
CO-3	3	3	3	2	-	2	2	2	2	2	2	3	3	3	3
CO-4	3	3	3	2	-	2	2	2	2	2	2	3	3	3	3
CO-5	3	3	3	2	-	3	3	2	2	2	2	3	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXTBOOKS:

1. "An Introduction to Statistical Learning: with Applications in R" by Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani, Springer.
2. "Neural Networks and Deep Learning: A Textbook" by Charu C. Aggarwal, Springer.

REFERENCE BOOKS:

1. "Pattern Recognition and Machine Learning" by Christopher M. Bishop, Springer.
2. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy, The MIT Press.

LABORATORY EXPERIMENTS

Total Contact Hours: 26

List of Laboratory/Practical Experiments activities to be conducted:

1. Implementation of Linear and Logistic Regression
Lab Exercise: Use real-world datasets to implement and evaluate linear regression models, followed by logistic regression for binary classification tasks.
2. Implementation of SVM, KNN, and Naïve Bayes ML Algorithms
Lab Exercise: Apply Support Vector Machines (SVM), K-Nearest Neighbors (KNN), and Naïve Bayes classifiers to different datasets, analyzing the impact of parameter tuning on model performance.
3. Implementation of Decision Trees and Random Forest Classifiers
Lab Exercise: Build and test decision tree models; extend this to implement and optimize random forest classifiers, comparing their effectiveness against simpler models.
4. Implement Ensemble Algorithms
Lab Exercise: Develop ensemble learning solutions using techniques such as bagging, boosting, and stacking; focus on comparing their predictive accuracies across various datasets.
5. Implementation of Different Clustering Algorithms and PCA
Lab Exercise: Execute clustering methods like K-means, hierarchical, and DBSCAN; integrate PCA for dimensionality reduction on complex datasets to improve clustering performance.
6. Implementation of Different Neural Networks
Lab Exercise: Construct and train basic neural networks, including multi-layer perceptron's; explore the use of different activation functions and the effects of various network architectures.
7. Feature Engineering and Data Preparation
Lab Exercise: Perform feature selection and feature engineering tasks to enhance model accuracy; include exercises on encoding, scaling, and handling missing values.
8. Implementation of a Machine Learning Pipeline
Lab Exercise: Design and build a complete machine learning pipeline, from data ingestion and preprocessing to model training and evaluation, using a dataset to predict outcomes effectively.

FUNDAMENTALS OF ROBOT MECHANICS

[As per Choice Based Credit System (CBCS) scheme]
(Lab Integrated Core Course)

SEMESTER – III

Subject Code	: 23RA2305	Credits	: 04
Hours / Week	: 05	Total Hours	: 39+26 = 65
L-T-P-J	: 3-0-2-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This Course will enable students to:

1. **Equip** students with an understanding of the basic mechanics of materials principles, emphasizing their application in robotic design and analysis.
2. **Develop** proficiency in stress and strain analysis under various loading conditions, using tools like Mohr's circle for engineering applications in robotics.
3. **Enhance** knowledge of beam theory, focusing on bending, deflection, and the impact of dynamic loads on robotic structures.
4. **Introduce** the fundamentals of Finite Element Analysis (FEA), covering its history, importance, and practical steps for modelling robotic components.
5. **Prepare** students to apply FEA in real-world robotic design scenarios, focusing on result interpretation, design optimization, and best practices in engineering analysis.

Teaching-Learning Process (General Instructions)

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

- **Lecture method** means it includes not only traditional lecture method, but different *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

Introduction to Mechanics of Materials in Robotics

Basics of mechanics of materials in the context of robotics, emphasizing stress, strain, material properties, and the impact of different types of loads on robotic structures.

UNIT - II		08 Hours
Stress and Strain Analysis Axial loading, shear and torsion stresses, and the concept of stress transformations, including the application of Mohr's circle for plane stress and strain conditions.		
UNIT - III		06 Hours
Beam Bending and Deflection Bending stresses in beams, shear stress considerations, and methods for calculating beam deflection, alongside a discussion on the significance of dynamic loading in robotic structures.		
UNIT - IV		09 Hours
Introduction to Finite Element Analysis in Robotics Fundamentals of FEA: History, importance, and basic principles, Introduction to FEA software tools and environments, creating simple FEA models: Geometry creation, meshing basics, Applying materials and boundary conditions.		
UNIT - V		08 Hours
Practical Applications of FEA in Robotics Simple case studies demonstrating the use of FEA in robotics. Basic interpretation of FEA results: Understanding stress, strain, and displacement. Introduction to modifying designs based on FEA results for improved performance. Best practices for using FEA in robotic component design and analysis.		

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply mechanics of materials principles to analyze and solve problems related to stress, strain, and deformation in robotic structures.	L2 & L3
2	Utilize Mohr's circle and other stress transformation techniques to assess complex loading conditions in robotics applications.	L2 & L3
3	Analyze beam bending and deflection in robotic elements, incorporating the effects of dynamic loading for realistic engineering assessments.	L2 & L3
4	Conduct Finite Element Analysis (FEA) on robotic components, demonstrating proficiency in modeling, meshing, and applying boundary conditions.	L2 & L3
5	Interpret FEA results to make informed decisions for the optimization and improvement of robotic component designs, ensuring performance and reliability.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	3	3	3	2	2	-	-	2	2	2	3	3	3
CO-2	3	3	3	2	3	2	2	-	-	2	2	2	3	3	3
CO-3	3	3	3	3	3	2	2	-	-	2	2	2	3	3	3
CO-4	3	3	3	3	3	3	3	-	-	2	2	2	3	3	3
CO-5	3	3	3	3	3	3	3	-	-	2	2	2	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. "Mechanics of Materials", by Ferdinand P. Beer, E. Russell Johnston, Jr., John T. DeWolf, and David
2. F. Mazurek. Publisher: McGraw-Hill Education; 7th Edition. An Introduction to the Finite Element Method by J. N. Reddy. Publisher: McGraw-Hill Education; 4th Edition.

REFERENCE BOOKS:

1. "Roark's Formulas for Stress and Strain", 8th Edition by Warren C. Young and Richard G Budynas. Publisher: McGraw-Hill Education.
2. "Fundamentals of Robotics: Analysis and Control", by Robert J. Schilling. Publisher: Prentice Hall; 1st Edition.

LABORATORY EXPERIMENTS

Total Contact Hours: 26

List of Laboratory/Practical Experiments activities to be conducted:

Lab Exercise 1: Using Python, perform basic calculations and visualizations of stress and strain under different loading conditions on simple geometric robotic components. Introduce libraries like NumPy and Matplotlib for these tasks.

Lab Exercise 2: Implement Mohr's circle for stress and strain analysis in Python. Students will calculate and plot the stress states for different robotic components under axial, shear, and torsional loads.

Lab Exercise 3: Use Ansys for a hands-on session where students apply axial, shear, and torsional loads to a predefined model of a robotic arm, analyzing stress distributions and transformations.

Lab Exercise 4: Use Python to calculate bending stresses and shear stresses in beams. Implement formulas for beam deflection and visualize the results for dynamic loading scenarios.

Lab Exercise 5: In Ansys, model a robotic beam under various loading conditions to study bending, shear stresses, and deflections.

Exercise 6: Guide students through the process of creating a simple geometric model in Ansys, perform meshing, and apply material properties and boundary conditions. Analyze a basic part of a robotic structure using FEA.

Lab Exercise 7: Conduct FEA on a more complex robotic component in Ansys. Students will interpret stress, strain, and displacement results and propose design modifications.

Lab Exercise 8: Using Python, students will write scripts to automate the preprocessing steps for FEA in Ansys, such as generating mesh statistics or setting up simulations based on different load scenarios.

Skill Enhancement course – I

PLC Programming for Automated Systems [As per Choice Based Credit System (CBCS) scheme] Semester – III			
Subject Code	: 23RA2307	Credits	: 02
Hours / Week	: 03	Total Hours	: 13+ 26
L-T-P-J	: 1-0-2-0	CIE	: 100 Marks
Course Objectives: This Course will enable students to: 1. Understand the basic components and functions of PLCs and their applications in industrial automation. 2. Develop proficiency in using Ladder Logic and other PLC programming languages to create control programs. 3. Implement basic and advanced PLC programming concepts, including bit logic operations, timers, counters, and analog signal processing. 4. Utilize simulation software for testing and debugging PLC programs, and apply systematic troubleshooting methods. 5. Integrate safety measures, best practices, and communication protocols to ensure reliable and efficient operation of automated systems.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes. • Lecture method means it includes not only traditional lecture method, but different <i>type of teaching methods</i> may be adopted to develop the course outcomes. • Interactive Teaching: Adopt the Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. • Show Video/animation films to explain functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher order Thinking questions in the class. • Adopt Problem Based Learning, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.			
Course Summary PLC programming for automated systems involves understanding and utilizing the fundamental components and functions of a Programmable Logic Controller (PLC). This includes recognizing the differences between various types of PLCs and their specific applications in industrial automation. Key hardware components such as the CPU, power supply, I/O modules, and communication interfaces must be identified and described, along with how PLCs interface with other industrial equipment and sensors. Proficiency in programming languages such as Ladder Logic, is essential for developing effective control programs. Basic programming concepts like creating and interpreting Ladder Logic diagrams, and using bit logic operations, timers and counters are fundamental. Simulation software is used to test and debug programs offline, while systematic troubleshooting methods help diagnose and fix issues. Safety measures and best practices, such as code documentation and modularization, are essential to ensure reliable operation. Additionally, understanding PLC networking and communication protocols like Ethernet/IP, Modbus, and Profibus is vital for integrating PLCs with other automation systems and devices.			

List of Problems

1. Design a PLC ladder diagram to construct an alarm system which operates as follows
 - . If one input is ON nothing happens
 - . If any two inputs are ON, a red light goes ON
 - . If any three inputs are ON, an alarm sirens sound
 - . If all are ON, the fire department is notified

2. In certain process control application, a fan is to run only when all of the following conditions are met
 - . Input **A** is OFF
 - . Input **B** is ON or i/p **C** is ON, or both **B & C** are ON
 - . Inputs **D & E** both are ON
 - . One or more of inputs **F, G, or H** is ON

3. Design a PLC ladder diagram to realize the following Timer operation. Write timing diagrams.
 - i) One shot operation
 - ii) Limited ON time

4. There are 3 mixing devices on a processing line **A, B, C**. After the process begin mixer-**A** is to start after 7 seconds elapse, next mixer-**B** is to start 3.6 second after **A**. Mixer-**C** is to start 5 seconds after **B**. All then remain ON until a master enable switch is turned off. Write PLC ladder diagram, timing diagram and realize the same

5. An indicating light is to go ON when a count reaches 23. The light is then go off when a count of 31 is reached. Design, construct, and test PLC circuits for this process

6. In certain process control application when the count reaches 25, a paint spray is to run for 40 seconds. Design, construct, and test PLC circuits for this process

7. Three conveyors feed a main conveyor. The count from each feeder conveyor is fed into an input register in the PLC. Construct a PLC program to obtain the total count of parts on the main conveyor. Use a time to update the total every 15 seconds. Design, construct, and test PLC circuits for this process.

8. In certain process control application o/p is ON if the count is less than 34 or more than 41. Implement the same using PLC ladder diagram

9. A conveyor is supposed to have exactly 45 parts on it. You have three indicating lights to indicate the conveyor count status: less than 45, yellow: exactly 45, green: and more than 45, red. The count of parts on the conveyor is set at 45 each morning by an actual count of parts. There are two sensors on the conveyor, one is actuated by parts entering the conveyor, and the other is actuated by parts leaving. Design a PLC program to carry out this process.

10. Design a PLC program for the following real time applications
 - i) Traffic light controlling
 - ii) Water level controlling

Course Outcomes

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Students will understand and explain the basic components, functions, and architecture of PLCs.	L2 & L3
2	Students will identify and describe the hardware components of a PLC system and their interfaces with industrial equipment.	L2 & L3
3	Students will demonstrate proficiency in using Ladder Logic and other PLC programming languages to create control programs.	L3
4	Students will implement advanced PLC programming techniques and develop modular and reusable code structures.	L4
5	Students will understand and apply safety measures and communication protocols in PLC programming and integration.	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	2	2	-	2	2	1	1	1	1	1	2	2	2
CO-2	3	3	2	2	-	1	2	-	-	1	2	1	2	3	3
CO-3	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3
CO-4	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3
CO-5	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

Hydraulics and Pneumatics for Robotics

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

SEMESTER – III

Subject Code	: 23RA2308	Credits	: 02
Hours / Week	: 03	Total Hours	: 13+26 = 39
L-T-P-J	: 1-0-2-0	CIE	: 100 Marks

Course Objectives:

This Course will enable students to:

1. **Understand** Principles: Learn the fundamental principles and components of hydraulic and pneumatic systems.
2. **Design** Systems: Develop the ability to design and analyze hydraulic and pneumatic circuits for various applications.
3. **Apply** Technologies: Identify appropriate applications for hydraulic and pneumatic systems in robotics and justify their use.
4. **Integrate** Controls: Integrate hydraulic and pneumatic systems with control technologies to optimize robotic performance.
5. **Perform** Maintenance: Acquire skills for the maintenance, troubleshooting, and repair of hydraulic and pneumatic systems in robotic contexts.

Course Summary:

This course provides a comprehensive introduction to the principles and applications of hydraulic and pneumatic systems in robotics. Students will begin by exploring the fundamental concepts and components of these systems, including pumps, compressors, actuators, valves, and control mechanisms. Emphasis will be placed on understanding the physical principles that govern the operation of hydraulic and pneumatic systems, as well as their advantages and limitations compared to other power transmission methods.

Building on this foundational knowledge, the course will delve into the design and analysis of hydraulic and pneumatic circuits. Students will learn to create and evaluate these systems for various robotic applications, such as industrial automation, mobile robotics, and medical devices. In the latter part of the course, students will focus on the fundamentals of hydraulic and pneumatic systems. By the end of the course, students will be well-equipped with the knowledge and skills to design, implement, and maintain hydraulic and pneumatic systems in a variety of robotic contexts.

Important basic terms

1. Characteristics of Industrial Hydraulics
2. Comparison of Hydraulics Vs Electrical / Electronics, Pneumatics and Mechanical
3. Applications of Hydraulics

Basic physical properties

- I. Pressure.
- II. Pascal's Law.
- III. Force transmission
- IV. Pressure transmission
- V. Displacement Transmission
- VI. Calculations
- VII. Flow rate and Flow Law.
- VIII. Graphical Symbols and Hydraulic circuits.
- IX. Hydraulic Fluids
- X. Hydraulic pumps

XI. Hydraulic Cylinder and Motor

Hydraulic Control valves:

- I. PCV
- II. FCV
- III. DCV

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the basic principles and components of hydraulic and pneumatic systems and their roles in robotics.	L2 & L3
2	Design and analyze hydraulic and pneumatic circuits for various robotic applications.	L2 & L3
3	Identify and justify the use of hydraulic and pneumatic systems in different robotic contexts.	L3
4	Integrate hydraulic and pneumatic systems with electronic control units and sensors for optimized performance.	L4
5	Perform maintenance, troubleshoot issues, and repair hydraulic and pneumatic systems to ensure reliable operation.	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	2	2	-	2	2	1	1	1	1	1	2	2	2
CO-2	3	3	2	2	-	1	2	-	-	1	2	1	2	3	3
CO-3	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3
CO-4	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3
CO-5	3	3	2	3	-	1	2	-	-	1	2	2	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

IV-Semester Syllabus

TRANSFORMS AND NUMERIAL TECHNIQUES

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

SEMESTER – IV

Subject Code	: 23RA2401	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks

Course 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

09 Hours

Laplace Transform and Inverse Laplace Transform

Laplace Transforms of Elementary functions (without proof), (**Text Book-1: Chapter 6: 203 to 207**).

Laplace Transforms of $e^{at}f(t)$, $t^n f(t)$ and $f^{(t)}$, Periodic functions, Unit step function and impulse functions (**Text Book-1: Chapter 6: 208-230**).

Inverse Laplace Transforms- By the method of Partial Fractions, Logarithmic and Trigonometric functions, Convolution Theorem, Inverse Laplace transform using Convolution Theorem (Text Book-1: Chapter 6: 238). Solution to Differential Equations by Laplace Transform. (Text Book-1: Chapter 238-242).	
UNIT – II	09 Hours
Fourier Series Periodic Functions, Trigonometric Series (Text Book-1: Chapter 11: 495). Fourier series Standard function, Functions of any Period 2L, Even and Odd functions, Half-range Expansions. (Text Book-1: Chapter 11: 483-492) Practical Harmonic analysis (calculate average power and RMS values of periodic waveforms)	
UNIT – III	06 Hours
Fourier Transform Calculation of Fourier integrals using complex exponential form (Text Book-1: Chapter 11:510). Fourier transform of basic functions (Text Book-1: Chapter 11: 510-516). Fourier sine and cosine transforms. (Text Book-1: Chapter 11: 518-522).	
UNIT – IV	07 Hours
Numerical Methods for Solving Ordinary Differential Equations Euler's Method-Basic principles of Euler's method for solving first-order ODEs (Text Book-1:Chapter 1:10-12). Runge-Kutta 4th order (Text Book-1: Chapter 21:904). Multistep Methods-Explanation of multistep methods (Adams-Bashforth, Adams-Moulton Methods) (Text Book-1: Chapter 21:911-913). Second-Order ODE. Mass-Spring System (Euler Method, Runge-Kutta Methods) (Text Book-1: Chapter 21:916-918).	
UNIT – V	08 Hours
Numerical Methods for Partial Differential Equations Classification of PDEs (elliptic, parabolic, hyperbolic), (Text Book-1: Chapter 21:922-923). Finite Difference Methods (Laplace and Poisson Equations), Derivation of finite difference approximations (Text Book-1: Chapter 21:923-927). Crank-Nicolson Method (Text Book-1: Chapter 21:938-941). Method for Hyperbolic PDEs (Text Book-1: Chapter 21:943-945).	

Course Outcome

Course Outcomes (COs)	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

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	3	3	-	2	2	-	-	2	2	3	3	2	2
CO-2	3	3	3	3	-	2	2	-	-	2	2	3	3	2	2
CO-3	3	3	3	3	-	2	2	-	-	2	2	3	3	2	2
CO-4	3	3	3	3	-	2	2	-	-	2	2	3	3	2	2
CO-5	3	3	3	3	-	2	2	-	-	2	2	3	3	2	2

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

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

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>

MECHATRONICS AND SMART MANUFACTURING

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

SEMESTER – IV

Subject Code	: 23RA2402	Credits	: 03
Hours / Week	: 03 Hours	Total Hours	: 39 Hours
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This Course will enable students to:

- **Understand** the integration of mechanical, electronic, and computational components to create efficient mechatronic systems in robotics.
- **Gain** knowledge of various sensors and actuators, including their types, functionalities, and applications in robotic systems.
- **Explore** the operational principles and applications of different types of motors used in robotics to select appropriate actuators for specific tasks.
- **Comprehend** the fundamental concepts and technologies behind smart manufacturing, focusing on how this impact the production and operation of robotic systems.
- **Analyse** the challenges and opportunities presented by smart manufacturing technologies, with a view to implementing innovative solutions in robotics.

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

Fundamentals of Mechatronics in Robotics

Introduction to Mechatronics: Core principles and components, with a focus on the integration in robotic systems. Some examples of mechatronic systems

Embedded Systems in Robotics: Overview of embedded computing in robotics, covering microcontrollers and system on a chip (SoC).

UNIT – II

08 Hours

Sensor Technology and Sensor Fusion

Smart Sensors: Exploration of sensor types and functionalities, with applications in robotics.

Sensor Fusion Theories: Detailed theoretical background on integrating data from multiple sensors to enhance decision-making and system reliability.

UNIT - III	10 Hours
Motors and Actuators in Robotics Operational Principles of Actuators: Exploration of various actuators beyond motors, such as pneumatic and hydraulic actuators, piezoelectric actuators, and their specific uses in robotic systems. Types of Motors and Their Applications: Detailed overview of different types of motors used in robotics, including stepper motors, servo motors, and brushless DC motors. Selection and Integration of Actuators: Theoretical considerations for selecting the appropriate actuator type based on performance, efficiency, and application requirements in robotic designs.	
UNIT - IV	7 Hours
Introduction to Smart Manufacturing Concepts of Smart Manufacturing: Overview of automation, data exchange, and the integration of digital technologies in manufacturing. Key Technologies: Examination of the Internet of Things (IoT), Artificial Intelligence (AI), and their applications in enhancing manufacturing processes. Robotics in Smart Manufacturing: Focus on how robotics are integrated into smart manufacturing, including the use of additive manufacturing (3D printing) and CNC machining.	
UNIT - V	6 Hours
Theory and Design of Integrated Mechatronic Systems Design Principles of Mechatronic Systems: Theoretical foundations for designing integrated systems that combine mechanics, electronics, and computer control in robotics. System Analysis and Modeling: Methods for analyzing and modeling mechatronic systems, focusing on predictive modeling and simulation techniques.	

Course Outcomes

Course Outcome (CO)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the knowledge of sensors and actuators to design and optimize robotic systems, enhancing their functionality and efficiency in real-world scenarios.	L2 & L3
2	Demonstrate the ability to integrate and program embedded systems, controlling mechatronic components within robotic applications.	L2 & L3
3	Utilize smart manufacturing technologies to develop innovative manufacturing solutions, effectively incorporating robotics and automation into production processes.	L2 & L3
4	Implement and analyze the performance of motors and other actuators in robotic applications, choosing the best fit based on specific operational requirements.	L2 & L3
5	Evaluate and adapt to the challenges presented by smart manufacturing environments, applying cybersecurity and scalability strategies to maintain and improve system integrity.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	2	-	-	-	-	-	-	-	-	-	3	3	3
CO-2	-	-	-	3	2	-	-	-	-	-	-	-	3	3	3
CO-3	3	3	2	-	-	2	-	-	-	-	-	-	3	3	3
CO-4	3	-	-	2	-	-	2	-	2	-	-	-	3	3	3
CO-5	-	-	3	2	5	-	-	-	-	-	-	-	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXTBOOKS:

1. "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, 7th Edition" by W. Bolton, published by Pearson.
2. "Mechatronics Principles and Applications, Godfrey C. Onwubolu, Elsevier Butterworth-Heinemann Linacre House, Jordan Hill, Oxford OX2 8DP, 30 Corporate Drive, Burlington, MA 01803, First published 2005.

REFERENCE BOOKS:

1. "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 6th Edition" by Mikell P. Groover, published by Wiley.
2. "Robotics and Automation Handbook" by Thomas R. Kurfess, published by CRC Press.

KINEMATICS AND DYNAMICS FOR ROBOTICS

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

(Lab Integrated Core Course)

SEMESTER – IV

Subject Code	: 24RA2403	Credits	: 04
Hours / Week	: 05	Total Hours	: 39+26
L-T-P-J	: 3-0-2-2	CIE+SEE	: 60+40 Marks

Course Objectives:

This Course will enable students to:

- **Master** the fundamental principles of robot kinematics, including coordinate transformations, forward, and inverse kinematics.
- **Develop** proficiency in understanding and applying differential kinematics and robot control techniques.
- **Acquire** skills in trajectory planning and motion control for robotic systems.
- **Gain** in-depth knowledge of dynamic modeling and analysis of robots using various computational tools.
- **Cultivate** the ability to design, simulate, and analyze complex robotic systems in practical, real-world scenarios.

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 analyze 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

Evolution of Robots and Robotics-Laws of Robotics-Progressive Advancements in Robotics, Types of Robot Technology, Robot classifications and specifications, Design and control issues, Various manipulators, Sensors, work cell, Programming languages.

UNIT – II	08 Hours
Robot Kinematics: Mechanical structures and notations, Description of links and joints- Mathematical representation of Robots, Position and orientation, Homogeneous transformation, Various joints, Representation using the Denavit-Hartenberg (DH) parameters.	
UNIT – III	07 Hours
Manipulator Differential Motion and Statics: Linear and angular velocities, Relationship between transformation matrix and angular velocity, Mapping velocity vector, Manipulator Jacobian, Prismatic and rotary joints, Inverse, Wrist and arm singularity	
UNIT – IV	08 Hours
Trajectory Planning: Definition and Planning Tasks, Various Terminologies: Path, Trajectory, Knot points or, Via points, Spline, Joint space trajectory planning, Trajectory generation, Path update rate etc. – Steps in trajectory planning: Task description, Selecting and employing a trajectory planning technique, Computing the trajectory, Joint Space Techniques: different steps - Use of p-degree polynomial as Interpolation Function.	
UNIT – V	08 Hours
Robot Dynamics and Advanced Topics in Robotics Kinematics: Lagrangian mechanics, 2DOF Manipulator: Dynamic model – Open loop and closed loop control, multi-body dynamics, Introduction to compliant and soft robotics, Current research trends and applications in robot kinematics and dynamics	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply theoretical knowledge of kinematics and dynamics to effectively program and control robotic movements and manipulations.	L2 & L3
2	Analyze and design complex trajectory plans for robots, ensuring efficient and accurate task execution	L2 & L3
3	Implement dynamic models and simulations to predict and optimize the performance of robotic systems in various applications.	L2 & L3
4	Integrate differential kinematics and control algorithms to enhance the precision and responsiveness of robotic systems.	L2 & L3
5	Demonstrate practical skills in configuring and troubleshooting robotic systems, utilizing advanced software and hardware tools.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	3	2	3	2	2	2	2	2	2	3	3	3	3
CO-2	3	3	3	2	3	2	2	2	2	2	2	3	3	3	3
CO-3	3	3	3	2	3	2	2	2	2	2	2	3	3	3	3
CO-4	3	3	3	2	3	2	2	2	2	2	2	3	3	3	3
CO-5	3	3	3	2	3	2	2	2	2	2	2	3	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

Textbooks:

1. "Robotics: Modelling, Planning and Control" by Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer.
2. "Fundamentals of Robotic Mechanical Systems: Theory, Methods, and Algorithms, 4th Edition" by Jorge Angeles, Springer..

References:

1. "Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, published by Wiley.
2. "Modern Robotics: Mechanics, Planning, and Control" by Kevin M. Lynch and Frank C. Park, published by Cambridge University Press.

LABORATORY EXPERIMENTS

Total Contact Hours: 26

Lab component:

1. To develop a robot CAD model using Matlab
2. To design a robot motion using sin function using Matlab
3. To drive robot of inverse mechanism using Matlab
4. To generate a trajectory for robot trajectory using Matlab
5. To design a manipulator of Jacobian and velocity kinematic using Matlab
6. To design articulated robot using Matlab
7. To design robotic arm with basic movement using Matlab
8. To develop a PID controller for robot manipulation using Matlab
9. To demonstrate the driving of a robot using dynamics using Matlab
10. To demonstrate the design a robot of forward kinematics in Matlab

Conduct Total 7 experiments / programs out of the 10 programs, but first 4 programs are mandatory and rest of 3 programs are to be chosen from rest of the 6 (5th to 10th) programs)

COMPUTER ORGANIZATION AND ARCHITECTURE

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

SEMESTER – IV

Course Code	: 23RA2404	Credits	: 04
Hours / Week	: 04	Total Hours	: 39
L-T-P-J	: 3-1-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This Course will enable students to:

1. **Understand** the Architecture and programming of ARM microprocessor.
2. **Develop** program using Arm instruction set and appreciate the advanced features provided in the ARM.
3. **Understand** the exception handling techniques.
4. **Study in** detail the concept of instruction level parallelism and concepts of pipelining.
5. **Understand** various cache memory mapping techniques and memory Organization

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** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I	05 Hours
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An Overview of Computing Systems

History of Computers, The Computing Device, The ARM7TDMI Programmers' Model: Introduction, Data types, Processor Modes, Registers, Program Status Registers, The vector Table.
 Assembler Rules and Directives: Structure of Assembly Language Modules, Registers, Directives and Macros. Loads, Stores and Addressing: LOADS and STORES instructions, Operand Addressing, ENDIANNESS (Text Book-1: 1.1 to 1.3; 2.1 to 2.6; 4; 5.3, 5.4, 5.5.)

UNIT – II	05 Hours
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Constants and Literal Pools

The ARM Rotation Scheme, Loading Constants and address into Registers Logic and Arithmetic: Flags and their Use, compare instructions, Data Processing Instructions Loops and Branches: Branching, Looping, Conditional Execution, Straight-Line Coding Subroutines and Stacks: Stack, Subroutines, Passing parameters to subroutines, The ARM APCS. (Text Book-1: 6.1 to 6.4; 7.1 to 7.4; 8.2 to 8.6; 10.1 to 10.5)

UNIT – III	05 Hours
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Mixing C and Assembly Language

Inline Assembler Embedded Assembler, Calling Between C and Assembly. Exception Handling: Interrupts, Error Conditions, Processor Exception Sequence, The Vector Table, Exception Handlers, Exception Priorities, Procedures for Handling Exceptions. (Text Book-1: 11.1 to 11.8; 14.1 to 14.4.)

UNIT – IV	12 Hours
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Pipelining: Basic and Intermediate Concepts

Introduction, The Major Hurdle of Pipelining, How Pipelining Implemented, what makes Pipelining hard to Implement, Extending the MIPS Pipeline to Handle Multicycle Operations, The MIPS R4000 Pipeline, Crosscutting Issues. (Text Book-2: C.1 to C.7)

UNIT – V	12 Hours
Memory Hierarchy Introduction, Cache Performance, Six basic cache Optimizations, Virtual Memory, Protection and examples of Virtual Memory, Fallacies and Pitfalls. (Text Book-2: B.1 to B.6)	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's TaxonomyLevel
At the end of the course the student will be able to:		
1	Apply knowledge of the internal architecture and organization of ARM microprocessors to utilize their components and functionalities.	L3
2	Apply the instruction set of ARM Microprocessor by writing Assembly language programs.	L3
3	Analyze and compare the various exception handling techniques.	L4
4	Examine the concept of instruction-level parallelism and analyze the principles of Pipelining techniques.	L4
5	Compare and Contrast memory hierarchy and its impact on computer cost/performance.	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	-	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	-	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	3	3	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	3	3	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	3	3	-	-	-	-	-	-	-	3	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. William Hohl, "ARM Assembly Language", 2nd Edition, CRC Press, 2009.
2. John L Hennessy, David A Patterson, "Computer Architecture, A Quantitative Approach", 5th Edition, Morgan Kaufmann publishers, 2012.

REFERENCE BOOKS:

1. David A Patterson, John L Hennessy, "Computer Organization and Design", 4th Edition, Morgan Kaufmann publishers, 2010.
2. Steve Furber, "ARM System-on-chip Architecture", 2nd Edition, Pearson Publications, 2000.
3. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, "Computer Organization", 5th Edition, Tata McGraw Hill, 2002.

ADVANCED DEEP LEARNING [As per Choice Based Credit System (CBCS) scheme] (Lab Integrated Core Course)	
SEMESTER – IV	
Course Code : 23RA2405	Credits : 04
Hours / Week : 05	Total Hours : 39+26
L-T-P-J : 3-0-2-0	CIE+SEE : 60+40 Marks
Course Objectives: This course will enable students to: 1. Understand the foundational concepts and architectures of neural networks, including CNNs and RNNs, and their applications in tasks like computer vision, NLP, and speech recognition. 2. Analyse the functionality of autoencoders and generative models, including VAEs and GANs, for applications such as data compression, anomaly detection, and feature extraction. 3. Explore advanced deep learning techniques, such as transfer learning, domain adaptation, and representation learning, for solving real-world problems across diverse domains.	
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 along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes. 2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.	
UNIT – I	08 Hours
Introduction Mathematical Foundations: Linear Algebra: Scalars, Vectors, Matrices, Tensors; Probability Distributions: Discrete variables, Probability Mass Functions, Continuous Variables, Probability Density Functions; Gradient Based Optimization; Review of Core Concepts: Deep Learning, Difference between ML & DL, Advantages and disadvantages; Multilayer Perceptron; Feedforward Neural; Back Propagation; Gradient Descent; Activation Functions; Optimization Algorithms; Hyperparameters; Regularization.	
UNIT – II	08 Hours
Convolutional Neural Networks (CNNs) Introduction to CNNs, Advantages and Disadvantages of CNN; Convolution Operation: Parameter Sharing, Equivariance; Pooling; Variants of the basic Convolution Function: Stride, Padding, Unshared Convolution, Tilted Convolution; Basic Architecture of CNN: Input layer, convolution layer, activation, pool layer etc.; Applications: Computer Vision: Object detection, Face recognition, Motion detection, Pose estimation, Semantic segmentation; Image Compression, Popular Architectures: AlexNet, DenseNet.	

UNIT – III	08 Hours
Recurrent Neural Networks (RNNs) Basics of RNNs: Unfolding computational graphs; Teacher forcing and networks with output recurrence, Computing the gradient in a RNN, Recurrent networks as directed graphical models, Advantages & disadvantages of RNN; Types of Recurrent Neural Networks: One to one, One to many, Many to one, Many to Many; Gated Architectures: LSTM, GRU; Feedforward NN vs RNN, Encoder Decoder architecture; Applications: Natural Language Processing (NLP), Time-Series Analysis, Speech and Audio Processing, Image and Video Processing.	
UNIT – IV	08 Hours
Autoencoders and Generative Models Autoencoders: Architecture of autoencoders, Undercomplete autoencoders; Regularized autoencoders: Sparse autoenc., Denoising autoenc., Regularizing by penalizing derivatives; Stochastic Encoders and Decoders; Denoising Autoencoders: Estimating the score; Contractive autoencoders; Few applications; Generative Models: Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), Applications: Data Compression, Image Denoising, Feature Extraction, Anomaly Detection, Dimensionality Reduction.	
UNIT – V	07 Hours
Advanced Topics and Applications Representation Learning: Greedy Layer-wise Pre-training, Transfer Learning and Domain Adaptation, Distributed Representation; Image Classification: Techniques, Advantages, Application areas, Usage of Deep learning; Social Network Analysis: SNA terminologies, other details; Speech Recognition: Basic architecture of ASR systems, Traditional ASR approach, Deep learning of ASR; Recommender System: Types, DL based approach; NLP by DL in details.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Define the evolution, application scope, and basic models of artificial neural networks, and illustrate their mathematical foundations, including linear algebra and optimization techniques.	L1
2	Explain the principles of convolution operations and pooling techniques in CNNs, and demonstrate their applications in image classification using popular architectures like AlexNet and DenseNet.	L2
3	Develop RNN architectures such as LSTMs and GRUs, and utilize them to solve challenges in sequential data processing tasks like Natural Language Processing (NLP), Time-Series Analysis, Speech and Audio Processing.	L3
4	Classify different types of autoencoders and generative models, such as VAEs and GANs, and analyze their functions in applications like data compression, image denoising, and feature learning.	L4
5	Evaluate advanced deep learning techniques, including representation learning, image classification, social network analysis, speech recognition, recommender systems, and NLP, by interpreting their effectiveness in various applications.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	-	1	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	3	2	1	3	-	-	-	-	-	-	1	3	3	3
CO-3	3	3	3	2	3	-	-	-	-	-	-	1	2	3	3
CO-4	3	3	3	2	3	-	-	-	-	-	-	1	2	3	2
CO-5	3	3	3	3	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, Publisher: MIT Press, ISBN: 978-0262035613, 1st Edition, 2016.
2. Simon Haykin, “Neural Networks and Learning Machines”, Publisher: Pearson, ISBN: 978-0131471399, 3rd Edition, 2008.
3. Mohamed Elgendy, “Deep Learning for Vision Systems”, Publisher: Manning Publications, ISBN: 978-1617298084, 1st Edition, 2020.

REFERENCE BOOKS:

1. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Publisher: Springer, ISBN: 978-0387310732, 1st Edition, 2006.
2. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow”, Publisher: O'Reilly Media, ISBN: 978-1492032649, 2nd Edition, 2019.
3. David Foster, “Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play”, Publisher: O'Reilly Media, ISBN: 978-1492041948, 1st Edition, 2019.

LABORATORY EXPERIMENTS / PROGRAMS

Total Contact Hours: 26

- 1) Program 1:** Title: Build a Feedforward Neural Network Using TensorFlow/Keras;
Description: Create a feedforward neural network for classifying the MNIST dataset using TensorFlow or Keras.
- 2) Program 2:** Title: Optimization Algorithm Comparison Using PyTorch;
Description: Use PyTorch to implement and compare different optimization algorithms (SGD, Adam, RMSprop) on a synthetic dataset. Visualize the training loss convergence for each optimizer using Matplotlib.
- 3) Program 3:** Title: Design and Train a CNN Using TensorFlow/Keras;
Description: Build and train a CNN for the CIFAR-10 dataset using TensorFlow/Keras. Include components like convolutional layers, pooling layers, dropout, and different activation functions. Program with changing kernel sizes and strides.
- 4) Program 4:** Title: Visualize Feature Maps Using PyTorch;
Description: Train a CNN on the MNIST dataset using PyTorch and visualize the learned feature maps for a given input image. Display feature maps from different layers to demonstrate hierarchical feature extraction.
- 5) Program 5:** Title: Text Generation Using LSTMs in Keras;
Description: Build a text generation model using LSTM layers in Keras. Train the model on a dataset like Shakespeare's works or song lyrics and generate text sequences.
- 6) Program 6:** Title: Time Series Forecasting with PyTorch;
Description: Use PyTorch to implement an LSTM-based model for time series forecasting (e.g., stock prices or weather data).
- 7) Program 7:** Title: Image Denoising Autoencoder Using TensorFlow/Keras;
Description: Build and train an autoencoder in TensorFlow/Keras to denoise images from a noisy version of the MNIST dataset. Visualize input, noisy, and denoised outputs side-by-side.
- 8) Program 8:** Title: Variational Autoencoder (VAE) Using PyTorch;
Description: Implement a VAE in PyTorch for generative tasks on the MNIST dataset. Visualize the latent space and generate new images by sampling latent variables.
- 9) Program 9:** Title: Generative Adversarial Networks (GANs) Using TensorFlow/Keras;
Description: Use TensorFlow/Keras to implement a GAN for generating synthetic images. Train the model on the MNIST dataset, visualizing generator outputs at different training stages.
- 10) Program 10:** Title: Transfer Learning with Pre-trained CNNs Using Keras;
Description: Use a pre-trained CNN model (e.g., AlexNet, DenseNet, or VGG16) in Keras to classify a custom image dataset.

(Conduct Total 7 experiments / programs out of the 10 programs, but first 4 programs are mandatory and rest of 3 programs are to be chosen from rest of the 6 (5th to 10th) programs)

Skill Enhancement Course – II

Prototyping with 3D Printing [As per Choice Based Credit System (CBCS) scheme] (Lab Integrated Course)			
SEMESTER – IV			
Subject Code	: 23RA2407	Credits	: 02
Hours / Week	: 03	Total Hours	: 13+ 26
L-T-P-J	: 1-0-2-0	CIE	: 100 Marks
Course Objectives: This Course will enable students to: 1. Understand 3D printing technology, including types of printers and materials. 2. Develop skills in designing 3D models using CAD software. 3. Plan and execute prototyping projects from design to final print. 4. Evaluate and optimize printed prototypes for improved performance. 5. Explore diverse applications and implications of 3D printing technology.			
Course Summary: 3D printing, also known as additive manufacturing, has revolutionized the process of prototyping by enabling the rapid creation of physical models directly from digital designs. This technology allows for the layer-by-layer construction of objects using materials such as plastic, metal, or resin. The main advantage of 3D printing in prototyping is its ability to produce complex geometries that would be difficult or impossible to achieve with traditional manufacturing methods. Designers and engineers can quickly iterate on their designs, testing and refining them with tangible prototypes. This process significantly reduces the time and cost associated with bringing a new product to market, as changes can be implemented swiftly and prototypes can be produced on-demand. Beyond the speed and cost benefits, 3D printing also facilitates greater innovation in product development. It allows for the creation of highly customized and intricate designs that can be tailored to specific needs and requirements. This flexibility is particularly valuable in fields such as aerospace, medical device development, and consumer electronics, where precision and customization are critical. Furthermore, 3D printing supports sustainable manufacturing practices by minimizing material waste and enabling the use of recycled or biodegradable materials. As 3D printing technology continues to advance, its role in prototyping will likely expand, offering even greater capabilities and efficiencies in the design and manufacturing process.			
Unit 1			05 Hours
Introduction and Basic Principles The Generic AM Process, steps in AM process, Rapid Prototyping, The Benefits of AM, Distinction Between AM and CNC Machining, Material, Speed. Complexity, Accuracy, Geometry, Programming, Example AM Parts, other Related Technologies. Reverse Engineering Technology, Computer-Aided Engineering.			
Unit 2			08 Hours
Additive Manufacturing Techniques Introduction to additive manufacturing, flexible manufacturing system, Manufacturing processes, Industry 4.0, Classification of various additive manufacturing techniques such as fused deposition modeling (FDM), laminated object manufacturing (LOM), selective laser sintering (SLS), stereolithography (SLA), direct metal printing, working principle, process parameters, types of materials used in FDM, types of 3D printers.			

Course Outcomes

Course Outcomes (Cos)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain 3D Printing Technology: Understand and articulate the principles, types, and materials of 3D printing.	L2 & L3
2	Design 3D Models: Develop proficiency in creating detailed 3D models using CAD software	L2 & L3
3	Manage Prototyping Projects: Plan, execute, and manage 3D printing prototyping projects effectively.	L3
4	Optimize Designs: Evaluate printed prototypes, identify flaws, and optimize designs for better performance.	L4
5	Explore Applications: Understand and explore the applications and broader implications of 3D printing across various industries.	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	2	2	3	2	2	1	1	1	1	1	2	2	2
CO-2	3	3	2	2	3	1	2	-	-	1	2	1	2	3	3
CO-3	3	3	2	3	3	1	2	-	-	1	2	2	2	3	3
CO-4	3	3	2	3	3	1	2	-	-	1	2	2	2	3	3
CO-5	3	3	2	3	3	1	2	-	-	1	2	2	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

PRACTICAL COMPONENT

1.Introduction to modelling:

Get a quick overview of the Fusion user interface, create a 2D sketch, 3D model and create a basic technical drawing.

Module outline:

Get a quick overview of the Fusion user interface, create a 2D sketch, 3D model, and create a basic technical drawing.

After completing this module, you'll be able to:

- Create a project in the data panel.
- Create and edit a sketch.
- Create and edit a 3D model.
- Produce a 2D drawing.

2.Introduction to parametric sketching

Dive deeper into creating robust and fully defined sketches with Fusion.

Module outline:

Dive deeper into creating robust and fully defined sketches with Fusion.

After completing this module, you'll be able to:

- Create a sketch reference plane.
- Create sketch parameters.
- Link dimensions and parameters.
- Create a sketch spline.
- Project sketch geometry.

3.Introduction to parametric modelling

Create a reciprocating saw link and trigger referencing bodies, sketches and images to create 3D geometry.

Module outline:

Create a reciprocating saw link and trigger referencing bodies, sketches and images to create 3D geometry.

After completing this module, you'll be able to:

- Use a canvas image.
- Project edges into a sketch.
- Create a sketch spline.
- Apply appearances and physical materials.

4.Introduction to freeform and direct modeling

Create a reciprocating saw model using freeform modeling tools.

Module outline:

Create a reciprocating saw model using freeform modeling tools.

After completing this module, you'll be able to:

- Create a form body.
- Use Edit Form.
- Insert edges.
- Merge edges and vertices.
- Use direct modeling tools.

5.Introduction to assembly modelling.

Use assembly modeling tools and features to create and drive mechanical motion for a reciprocating saw.

Module outline:

Use assembly modeling tools and features to create and drive mechanical motion for a reciprocating saw.

After completing this module, you'll be able to:

- Create a component.
- Create a joint.
- Edit joint limits.

- Drive a joint.
- Create a rigid group.

6.Design considerations

Design considerations for Additive manufacturing lesson in the Additive manufacturing with Autodesk® Fusion 360 course.

Highlights some of the common pitfalls when designing for additive manufacturing and describes how to avoid them using Fusion 360.

FUNDAMENTALS OF IOT [As per Choice Based Credit System (CBCS) scheme] (Lab Integrated Course) SEMESTER – IV			
Course Code	: 23RA2408	Credits	: 02
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 1-0-2-0	CIE+SEE	: 100 Marks
Course Objectives: This Course will enable students to: 1. Understand the fundamental concepts and building blocks of an IoT system. 2. Design and implement IoT solutions involving data acquisition, transmission, and storage. 3. Deploy data in cloud platforms (e.g., Thingspeak) for data handling and visualization. 4. Develop proficiency in using APIs to interact with IoT platforms and services. 5. Apply simulation techniques for modeling and analyzing IoT system behavior.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. - Showing Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. - Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
Course Summary: This Internet of Things (IoT) course provides a comprehensive, hands-on introduction to the fundamental concepts and practical applications of IoT. The curriculum is structured around a series of experiments designed to equip students with the skills necessary to design, implement, and analyze IoT systems. The course begins with IoT Platform Interaction & Data Handling, where students learn to transmit sensor data to cloud platforms, retrieve/write data via APIs, and visualize it effectively; it then transitions to Simulation & Signal Processing, covering simulation techniques, numerical methods, waveform analysis, and frequency spectrum analysis. Finally, the course explores Basic Hardware Interaction/Interface, teaching students to interface with components and control outputs. Upon completion, students can connect IoT devices to cloud platforms, utilize APIs, interpret data, simulate signals, and interface with hardware to build IoT solutions.			
IoT Lab Experiments These experiments cover fundamental concepts in IoT, ranging from data handling and visualization to simulation and signal processing.			
A. IoT Platform Interaction & Data Handling (Focus on Thingspeak)			
1. Sending Sensor Data to Thingspeak: Program an IoT board (e.g., ESP32, Arduino) to read physical sensor data (temp, humidity, etc.) and publish it to a Thingspeak channel via API (HTTP/MQTT).			
2. Scraping Data from Thingspeak: Develop a script or application to retrieve existing data points from a specified Thingspeak channel using its API (e.g., fetching JSON or CSV).			

3. Writing Data to a Thingspeak Channel: Programmatically send and write data (simulated, manual, or static) to a Thingspeak channel using the appropriate write API key.

4. Reading Data from One Channel and Writing to Your Own Channel (Thingspeak): Implement a process to fetch data from a source Thingspeak channel (read API) and then publish that data to your own designated Thingspeak channel (write API).

5. Plotting Two Graphs in a Single View (Thingspeak/Data Visualization Platform): Configure a data visualization interface (like Thingspeak charts or an external tool) to display two distinct data streams from an IoT data source simultaneously on a single plot.

6. Plotting Two Graphs in Two Separate Views (Thingspeak/Data Visualization Platform): Configure a data visualization interface to display two distinct data streams on separate graphical widgets or plots within a dashboard.

7. Weather Graph (Data Visualization): Acquire weather data (via sensor or API) and visualize it over time using graphical plots on a platform or custom application.

B. Simulation & Signal Processing

8. Integration of Velocity Equation for Displacement or Position (Simulation): Simulate velocity data and apply numerical integration techniques (e.g., Euler, trapezoidal) in a programming or simulation environment to calculate the corresponding displacement or position.

9. Simulation of Three Waves Using Three Scopes: Generate three different waveforms (e.g., sine, square, sawtooth) in a simulation environment and visualize each distinct waveform on a separate virtual oscilloscope instrument.

10. Simulation of Three Waves Using a Single Scope: Generate three different waveforms in a simulation environment and display all three concurrently on a single virtual oscilloscope instrument, often using different visual cues for distinction.

11. Add and Product of Three Waves (Simulation): Generate three waveforms in a simulation environment, perform mathematical addition and multiplication operations on them, and visualize the resulting composite waveforms.

12. Spectrum Analyzer of Audio (Software/Hardware): Analyze an audio signal using techniques like Fast Fourier Transform (FFT) to determine its frequency components and visualize the resulting frequency spectrum.

13. Music With Noise (Simulation/Processing): Introduce or simulate the addition of noise (e.g., white noise) to an audio (music) signal.

14. Music With No Noise (Simulation/Processing): Work with a clean audio signal or apply noise reduction techniques to an audio signal containing noise.

15. Simulation of Integration of Velocity Equation Displacement or Position: (Repeat of Experiment 7) - Focuses on implementing numerical integration to derive displacement/position from simulated velocity data.

C. Basic Hardware Interaction / Interface

16. Variable Knob Connected to Constant and Display (Simulation/Hardware): Use a variable input component (simulated knob/slider or physical potentiometer) to control a value, which is then displayed on a virtual or physical output device (display).

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Students will understand and explain the basic components, functions, and architecture of IOT.	L2 & L3
2	Students will identify and describe the hardware components of a IOT system and their interfaces with industrial equipment.	L2 & L3
3	Students will demonstrate proficiency in using MATLAB programming and other IOT programming languages.	L3
4	Students will implement advanced IOT programming techniques and develop modular and reusable code structures.	L4
5	Students will understand and apply safety measures programming and integration IOT applications.	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

- IoT and Edge Computing for Architects, Second Edition, By Perry Lea Chief Architect at Hewlett-Packard, Co-founder of Rumble,|2020|632 Pages
- INTERNET OF THINGS A HANDS-ON APPROACH, Arshdeep Bahga, Vijay Madiseti, 1st Edition VPT, 2022

REFERENCE BOOKS:

- Daniel Minoli, – “Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications”, ISBN: 978-1-118-47347-4, Willy Publications
- Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press.

3. Peter Waher, "Mastering Internet of Things: Design and create your own IoT applications using Raspberry Pi 3", 1st Edition, Packt Publishing Ltd, 2018
4. Peter Waher, Pradeeka Seneviratne, Brian Russell, Drew Van Duren, "IoT: Building
5. Arduino-Based Projects", 1st Edition, Packt Publishing Ltd, 2016.
Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016.
6. Keysight Technologies, "The Internet of Things: Enabling Technologies and Solutions for Design and Test", Application Note, 2016.
7. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", Wiley Publications, 2013

E-Resources:

1. http://www.cse.wustl.edu/~jain/cse570-15/ftp/iot_prot/index.html
2. https://onlinecourses.nptel.ac.in/noc22_cs53/preview
3. <https://nptel.ac.in/courses/106105166>

Activity Based Learning (Suggested Activities in Class)

1. Assignments (in writing and doing forms on the aspects of syllabus content and outside
2. the syllabus content. Shall be individual and challenging)
3. Student seminars (on topics of the syllabus and related aspects (individual activity))
4. Quiz (on topics where the content can be compiled by smaller aspects and data (Individuals or groups as teams))
5. Study projects (by very small groups of students on selected local real-time problems pertaining to syllabus or related areas. The individual participation and contribution of students shall be ensured (team activity))

V-Semester Syllabus

MOBILE ROBOTICS	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – V	
Course Code : 23RA3501	Credits : 04
Hours / Week : 04	Total Hours : 39
L-T-P-J : 3-1-0-0	CIE+SEE : 60+40 Marks
Course Objectives: This course will enable students to: 1. Analyze: Evaluate the strengths and weaknesses of different robot locomotion mechanisms for specific applications. 2. Apply: Implement and analyze the performance of basic path planning algorithms for navigating a robot in a simulated or real-world environment. 3. Design: Develop a simple kinematic model for a mobile robot and use it to predict its motion given a set of inputs. 4. Explain: Describe the role of different sensors in robot perception and how sensor data is used for localization and mapping. 5. Create: Design a basic robot control system that can achieve a specific task, such as following a line or avoiding obstacles.	
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.	
UNIT – I	08 Hours
Fundamentals of Robotics Introduction to Robotics, Robot locomotion: Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability.	
UNIT – II	08 Hours
Mobile Robot Kinematics and Dynamics Mobile robot kinematics and dynamics: Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots	
UNIT – III	08 Hours
Perception Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision-based sensors, uncertainty in sensing, filtering.	
UNIT – IV	08 Hours
Localization Odometric Position Estimation, Belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, Positioning Beacon Systems.	

UNIT – V		07 Hours
Introduction to Planning and Navigation Path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP), stochastic dynamic programming (SDP).		

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the fundamental concepts, history, and applications of mobile robots in various industries.	L1
2	Analyze and apply the kinematic and dynamic models of wheeled and legged mobile robots for motion control.	L1
3	Implement techniques for robot localization, mapping, and Simultaneous Localization and Mapping (SLAM).	L2
4	Develop algorithms for path planning, trajectory generation, and obstacle avoidance using techniques like A*, Dijkstra, and Probabilistic Roadmaps.	L6
5	Implement techniques for robot localization mapping, and Simultaneous Localization and Mapping (SLAM).	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011.
2. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011.
3. S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available online <http://planning.cs.uiuc.edu/>)
4. Thrun, S., Burgard, W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA, 2005.
5. Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds, 2012. H.
6. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005

REINFORCEMENT LEARNING [As per Choice Based Credit System (CBCS) scheme] (Lab Integrated Core Course) SEMESTER – V			
Course Code	: 23RA3502	Credits	: 04
Hours / Week	: 05	Total Hours	: 39+26
L-T-P-J	: 3-0-2-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Explore the foundational principles of reinforcement learning, including its applications in diverse domains such as robotics, gaming, and autonomous systems. 2. Investigate advanced reinforcement learning algorithms, including Deep Q-Networks (DQN) and Policy Gradient methods, to understand their theoretical and practical aspects. 3. Implement reinforcement learning techniques using OpenAI Gym and TensorFlow to build, train, and evaluate agents for real-world decision-making tasks.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			08 Hours
Foundations of Reinforcement Learning Introduction to RL: Key elements: Agents, environments, policies, rewards, value functions, and models. Types of environments, platforms, and libraries used in RL, Applications of RL: Real-world use cases and emerging trends. Getting started with RL tools: Setting up the machine with Anaconda, Docker, OpenAI Gym, Universe, and TensorFlow. Fundamentals of TensorFlow and visualizations using Tensor Board. Simulating agents in OpenAI Gym and building a basic video game bot.			
UNIT – II			08 Hours
Markov Decision Processes and Dynamic Programming Markov chains and Markov processes, Modeling RL problems with MDPs, Value functions, Q functions, and Bellman equations, Dynamic programming techniques: Value iteration and policy iteration, Application: Solving the Frozen Lake problem.			
UNIT – III			08 Hours
Monte Carlo and Temporal Difference Learning Monte Carlo methods: First visit and every visit MC prediction method. On-policy and off-policy, MC control methods, Application: Playing blackjack using Monte Carlo methods, Temporal Difference (TD) Learning: TD prediction. On-policy methods: SARSA, Off-policy methods: Q-learning, Application: Solving the taxi problem using Q-learning and SARSA.			

UNIT – IV	08 Hours
Deep Q-Networks and Advanced Architectures Deep Q-Networks (DQN): Architecture and components: Convolutional networks, experience replay, and target networks. Variants: Double DQN, Dueling DQN, Prioritized Experience Replay. Application: Building an agent to play Atari games. Deep Recurrent Q-Networks (DRQN): Differences between DQN and DRQN. Advanced techniques: Deep Attention Recurrent Q-Networks (DARQN). Application: Building an agent to play Doom.	
UNIT – V	07 Hours
Actor-Critic and Policy Gradient Methods Actor-Critic Architectures: Asynchronous Advantage Actor-Critic (A3C) network. Application: Training an agent to drive up a mountain. Policy Gradient Methods: Basics of policy gradient methods. Deep Deterministic Policy Gradient (DDPG) for continuous action spaces, Advanced policy optimization: Trust Region Policy Optimization (TRPO). Proximal Policy Optimization (PPO), Applications: Solving environments like Lunar Lander and Pendulum.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Levels
At the end of the course the student will be able to:		
1	Define key concepts of reinforcement learning, including agents, environments, rewards, and policies.	L1
2	Describe Markov Decision Processes (MDPs) and demonstrate dynamic programming techniques to solve RL problems.	L2
3	Apply Monte Carlo methods and Temporal Difference learning to solve RL problems in discrete environments.	L3
4	Analyze the architecture and performance of deep reinforcement learning models like DQN and DRQN.	L4
5	Evaluate actor-critic models and policy gradient techniques for solving advanced RL tasks.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	-	-	2	-	-	-	-	-	-	3	2	2	1
CO-2	3	3	-	2	-	-	-	-	-	-	-	2	3	3	3
CO-3	3	2	3	-	-	-	-	-	-	-	-	1	2	3	3
CO-4	3	3	3	2	-	-	-	-	-	-	-	-	2	3	2
CO-5	2	3	3	-	-	-	-	-	-	-	-	-	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Richard S. Sutton, Andrew G. Barto, "Reinforcement Learning: An Introduction," Publisher: MIT Press, ISBN: 978-0262039246, 2nd Edition, 2018.
2. Francois Chollet, "Deep Learning with Python," Publisher: Manning Publications, ISBN: 978-1617294433, 2nd Edition, 2021.
3. Max Lapan, "Deep Reinforcement Learning Hands-On," Publisher: Packt Publishing, ISBN: 978-1838826994, 2nd Edition, 2020.

REFERENCE BOOKS:

1. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms," Publisher: Cambridge University Press, ISBN: 978-1107057135, 1st Edition, 2014.
2. Christopher M. Bishop, "Pattern Recognition and Machine Learning," Publisher: Springer, ISBN: 978-0387310732, 1st Edition, 2006.

LABORATORY EXPERIMENTS / PROGRAMS

Total Contact Hours: 26

1. Experiment 1: Exploring OpenAI Gym Environments: Set up OpenAI Gym and explore classic control problems such as CartPole, MountainCar, and Acrobot. Develop a basic agent to interact with the environment using random or heuristic-based actions.
2. Experiment 2: Implementation of Q-Learning: Solve the FrozenLake environment using Q-learning. Experiment with different learning rates, discount factors, and exploration strategies (e.g., epsilon-greedy).
3. Experiment 3: Temporal Difference (TD) Learning: Implement SARSA and Q-learning to solve the Taxi-v3 environment. Compare on-policy (SARSA) and off-policy (Q-learning) methods and observe their behavior.
4. Experiment 4: Policy Gradient for Lunar Lander: Use TensorFlow or PyTorch to build a policy gradient-based agent for the Lunar Lander environment. Analyze how the agent learns to land safely by optimizing rewards.
5. Experiment 5: Deep Q-Networks for Atari Games: Implement a DQN agent to play an Atari game (e.g., Breakout or Pong). Experiment with techniques like experience replay, target networks, and reward clipping.
6. Experiment 6: Multi-Armed Bandit Problem: Implement exploration methods such as epsilon-greedy, UCB (Upper Confidence Bound), and Thompson Sampling. Simulate a scenario (e.g., selecting the best advertisement banner) to observe the effectiveness of each method.
7. Experiment 7: Actor-Critic Implementation: Train an agent using the Actor-Critic method in environments like Pendulum or Bipedal Walker. Visualize the training process using Tensor Board and analyze the policy and value functions.

Number of experiments may be increased as per requirement by the course coordinator.

CONTROL SYSTEMS FOR ROBOTICS

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

SEMESTER – V

Course Code	: 23RA3503	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This course will enable students to:

1. **Understand** the role of control systems in robotics and their importance in achieving precise motion, stability, and performance in various robotic applications.
2. **Explore** the design and integration of sensors, actuators, and feedback mechanisms for implementing efficient control strategies in robotic systems.
3. **Analyze** advanced control techniques, such as state-space methods, nonlinear control, and optimal control, to address complex problems in robotic systems across diverse domains.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I

08 Hours

Introduction to Control Systems: Definition of Control Systems in Robotics, Importance of Control Systems in Robotics, Classification: Open-loop vs Closed-loop Systems, Characteristics of Open-loop Systems, Characteristics of Closed-loop Systems, Concept of Feedback in Control Systems, Significance of Feedback in Robotic Applications, Basic Block Diagram of a Control System.

UNIT – II

08 Hours

Modeling in the Frequency Domain: Introduction, Laplace Transform Review, The Transfer Function, Electrical Network Transfer Functions, Translational Mechanical System Transfer Functions, Rotational Mechanical System Transfer Functions, Transfer Functions for Systems with Gears, Electromechanical System Transfer Functions, Electric Circuit Analogs, Nonlinearities, Linearization. Modeling in the Time Domain : Introduction, Some Observations, The State-Space Representation, developing the State-Space model, Converting a Transfer Function to State Space, Converting from State Space to a Transfer Function, Linearization, Case Studies.

UNIT – III

08 Hours

Reduction of Multiple Subsystems: Block Diagrams, Analysis and Design of Feedback Systems, Signal-Flow Graphs, Mason's Rule, Signal-Flow Graphs of State Equations, Steady State Error: Steady-State Error for Unity Feedback Systems, Static Error Constants and System Type, Steady-State Error Specifications, Root Locus Technique: Defining the Root Locus, Properties of the Root Locus, Transient Response Design via Gain Adjustment, Root Locus for Positive-Feedback Systems, Pole Sensitivity.

UNIT – IV	08 Hours
Stability Analysis : Introduction, Routh-Hurwitz Criterion, Special Cases, Additional Examples, Stability in State Space, Frequency Response Techniques : Asymptotic Approximations: Bode Plots (No Hand-drawing), Nyquist Criterion (No Hand-drawing), Stability, Gain Margin, and Phase Margin via Bode Plots (No Hand-drawing), Relation Between Closed-and Open-Loop Frequency Responses, Relation Between Closed-Loop Transient and Open-Loop Frequency Responses, Transient Response via Gain Adjustment,	
UNIT – V	07 Hours
Design of Control Systems: Design Specifications, Controller Configurations, Fundamental Principles of Design, Design with the PD Controller, Design with the PI Controller, Design with the PID Controller, Design with Phase-Lead, Phase-Lag and Lead - Lag Controllers, Nonlinear system analysis and Lyapunov stability, Concept of Controllability and Observability, Modern Control Techniques: Concept of Robust Control Systems for Robotics, Concept of Sliding Mode Control (SMC) and Adaptive Control for Robotics, Concept of Optimal Control for Robotics.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Levels
At the end of the course the student will be able to:		
1	Define the fundamental concepts of control systems, including open-loop and closed-loop systems, and identify their applications in robotics.	L1
2	Describe classical control techniques such as PID controllers and analyze their role in robotic systems through stability analysis methods like root locus and Bode plots.	L2
3	Apply knowledge of sensors, actuators, and control interfaces to design and integrate control systems for robotic platforms.	L3
4	Analyze state-space representations and nonlinear control techniques, and their effectiveness in addressing complex robotic control challenges.	L4
5	Evaluate advanced motion control techniques for mobile and collaborative robotic systems and design solutions for specific applications like industrial automation or autonomous vehicles.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	-	-	1	-	-	-	-	-	-	3	3	-	-
CO-2	3	3	-	2	-	-	-	-	-	-	-	2	3	-	-
CO-3	3	2	3	-	-	-	-	-	-	-	-	1	3	2	-
CO-4	3	3	2	3	-	-	-	-	-	-	-	1	3	3	2
CO-5	2	3	3	-	-	-	-	-	-	-	-	-	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Rafael Kelly, Victor Santibáñez, Julio Antonio Loría Pérez, "Control of Robot Manipulators in Joint Space," Publisher: Springer, ISBN: 978-1447158985, 2nd Edition, 2015.
2. John J. Craig, "Introduction to Robotics: Mechanics and Control," Publisher: Pearson, ISBN: 978-0133489798, 4th Edition, 2018.
3. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, "Robotics: Modelling, Planning and Control," Publisher: Springer, ISBN: 978-1846286414, 2nd Edition, 2010.

REFERENCE BOOKS:

1. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modeling and Control," Publisher: Wiley, ISBN: 978-0471649908, 1st Edition, 2005.
2. Kevin M. Lynch, Frank C. Park, "Modern Robotics: Mechanics, Planning, and Control," Publisher: Cambridge University Press, ISBN: 978-1107156302, 1st Edition, 2017.

ROBOT OPERATING SYSTEM(ROS) [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – V			
Subject Code	: 23RA3504	Credits	: 04
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-2	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Explain the core concepts and architecture of ROS, including nodes, topics, messages, services, and actions. 2. Describe the communication mechanisms in ROS (publishers, subscribers, clients, and servers) 3. Write and implement simple ROS nodes for sensor data acquisition, robot control, and communication between different components. 4. Integrate various sensors (e.g., cameras, IMUs, and LIDAR) and actuators into ROS nodes for real-time data processing and control. 5. Apply ROS-based packages for robot localization, mapping (SLAM), and path planning. 6. Develop algorithms for robot navigation, including obstacle detection and avoidance.			
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
Getting Started with ROS Hydro - 4 Installing ROS Hydro – using repositories, Real and Simulated Robots, Operating Systems and ROS Versions, ROS Application. ROS Architecture and Concepts: Understanding the ROS Filesystem level, Understanding the ROS Computation Graph level, Understanding the ROS Community level.			
UNIT – II			08 Hours
Controlling a Mobile Base Units and Coordinate Systems, Levels of Motion Control, Twisting and Turning with ROS, Calibrating Your Robot's Odometry, Sending Twist Messages to a Real Robot, Publishing Twist Messages from a ROS Node,. Working with 3D Robot Modeling in ROS: ROS packages for robot modelling, Understanding robot modeling using URDF, Creating the ROS package for the robot description, Creating our first URDF model, Explaining the URDF file, Visualizing the robot 3D model in Rviz, Interacting with pan and tilt joints, Adding physical and collision properties to a URDF model, Understanding robot modeling using xacro , Conversion of xacro to URDF.			

UNIT – III	10 Hours
Navigation, Path Planning and SLAM: Path Planning and Obstacle Avoidance using move base, Testing move base in the ArbotiX Simulator, Running move base on a Real Robot, Map Building using the gmapping Package, Navigation and Localization using a Map and amcl.	
UNIT – IV	7 Hours
Sensors and Actuators with ROS Using a joystick or a gamepad, Using Arduino to add sensors and actuators, Using a low-cost IMU – 9 degrees of freedom, Using the IMU – Xsens MTi, Using a GPS system, Using a laser rangefinder – Hokuyo URG-04lx.	
UNIT – V	6 Hours
Real-World Applications Deployment ROS-Based Cognitive Surgical Robotics, ROS in Space: A Case Study on Robonaut 2, ROS in the MONarCH Project: A Case Study in Networked Robot Systems, Case Study: Hyper-Spectral Mapping and Thermal Analysis.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Demonstrate the ability to install and configure ROS Hydro, including setting up repositories, managing versions, and working with real and simulated robots.	L2 & L3
2	Understand and apply ROS architecture at the filesystem, computation graph, and community levels.	L2 & L3
3	Implement and test navigation, path planning, and SLAM algorithms on simulated and real robots, including map building and localization using gmapping and amcl.	
4	Integrate and use various sensors and actuators, including joysticks, IMUs, GPS systems, and laser rangefinders, within the ROS framework.	L2 & L3
5	Apply ROS to real-world applications, including in areas like cognitive surgical robotics, space robotics, networked robot systems, and hyperspectral mapping.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3				-	-	-	-	-	-	-	3	3	3
CO-2	-	3	3	3	3	-	-	-	-	-	-	-	3	3	3
CO-3	-	3	3			-	-	-	-	-	-	-	3	3	3
CO-4	-	-	-	-	3	3	-	-	-	-	-	-	3	3	3
CO-5	-	-	-	-	-	-	3	3	-	-	-	-	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.

- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXTBOOKS:

1. Anees Khubha "Robot Operating System (ROS) The Complete Reference (Volume 5), springer.
2. R Patrick Goebel, "ROS by example" volume 1, API Robot Production

REFERENCE BOOKS:

1. Morgan Quigley, Brian Gerkey, and William D Smart "Programming robotics with ROS", O'Reily Media.

ROBOTIC VISION [As per Choice Based Credit System (CBCS) scheme] (Lab Integrated Core Course)	
SEMESTER – V	
Course Code : 23RA3505	Credits : 04
Hours / Week : 05	Total Hours : 39+26
L-T-P-J : 3-0-2-0	CIE+SEE : 60+40 Marks
Course Objectives: This course will enable students to: 1. Explain the significance and various components of machine vision system 2. Discuss image acquisition and digital image processing operators 3. Discuss image segmentation and analysis techniques 4. Discuss robot programming and vision algorithms for robot vision 5. Apply the concepts of machine vision and image processing in various industrial 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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.	
UNIT – I	08 Hours
Introduction to Computer Vision Human visual system, comparison with a machine vision system, Computer Vision, Industrial Machine Vision vs. Image understanding, components of machine vision system in context of a manufacturing environment. Illumination and sensors: Control of illumination and light levels, Image formation- elementary objects, camera sensors- CCD, CMOS, characteristics of camera sensors.	
UNIT – II	08 Hours
Image Acquisition Sampling and quantization, Inter pixel distances, adjacency conventions. Image acquisition hardware, speed considerations. Digital image processing: Basics of digital image, Point operations- contrast stretching, thresholding, noise suppression by image addition, background subtraction. Neighborhood operations- convolution, noise suppression	
UNIT – III	08 Hours
Image Segmentation An overview of edge detection techniques: Gradient and difference-based Operators-Roberts estimate operators, template matching, edge fitting, assessment of edge detection Image Analysis: Introduction- inspection, location and identification, image analysis techniques template matching, components of statistical pattern recognition process, Houghs transform technique.	
UNIT – IV	8 Hours
Robot programming and robot vision Brief review of robot programming methodologies, homogeneous transformations, robotic programming language- RCL: data types and variable declarations, arithmetic expression	

statements, frame expression statements. Vision algorithms: Vision algorithms for identifying end wires- binary vision algorithm, grey scale vision algorithm, active ranging using structured light technique in industrial vision.

UNIT - V	7 Hours

Machine vision in manufacturing

Types of tasks- code recognition, object recognition, position recognition, completeness check, shape and dimension check, surface inspection. Types of production, types of evaluation, Value-Adding machine vision. Case Studies: Machine vision applications to industries: Condition monitoring, metrology and gauging, OCR and OCV, Augmented reality, Surveillance.

LABORATORY EXPERIMENTS / PROGRAMS

Total Contact Hours: 26

1. Image Fundamentals & Basic Video Playback: Load, display, and save images; apply negative/brightness/contrast to images; read and play video files frame by frame.
2. Geometric Transformations (Image) & Frame Manipulation (Video): Implement image translation, scaling, and rotation; apply basic image operations (like grayscale conversion or simple filters) to individual video frames.
3. Spatial Filtering (Image) & Basic Video Enhancement: Apply average, Gaussian, Laplacian, and Median filters for image smoothing, sharpening, and noise reduction; use these filters on video frames to observe real-time effects.
4. Contrast Enhancement (Image) & Simple Video Effects: Compute and apply histogram equalization for image contrast improvement; implement effects like color channel manipulation or simple frame differencing in video.
5. Frequency Domain Processing (Image) & Motion Detection (Video): Perform 2D FFT, visualize spectra, and apply ideal low/high-pass filters to images; implement basic motion detection in video using techniques like background subtraction or successive frame differencing.
6. Hardware-Accelerated Image Filtering (PYNQ): Implement and benchmark a standard image filter (e.g., Gaussian blur or Sobel edge detection) using a PYNQ overlay's hardware accelerated IP, comparing its performance against a pure software (OpenCV) implementation.
7. Real-time Video Processing with PYNQ HDMI: Capture live video from an HDMI input, apply a specific image processing operation (e.g., color thresholding or basic filtering) using PYNQ's on-board processing, and stream the processed video to an HDMI output.
8. Hardware-Accelerated Grayscale Conversion (PYNQ): Implement grayscale conversion using a PYNQ overlay's hardware accelerated IP, demonstrating the performance gain over software-only

OpenCV.

9. Hardware-Accelerated Color Space Conversion (PYNQ): Convert video streams between different

color spaces (e.g., RGB to YCbCr, or to grayscale) using PYNQ's pre-built video processing IP,

showcasing efficient on-board conversion.

10. Custom IP Integration for Image Transformation (PYNQ): Develop a simple custom HLS IP for a

specific image transformation (e.g., image resizing with custom interpolation, or a specific

11. morphological operation), integrate it into a PYNQ overlay, and demonstrate its use for accelerated

image processing.

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the basic principles of image formation, camera models, and vision-based perception in robotics.	L1
2	Perform camera calibration, lens distortion correction, and basic image processing techniques such as filtering, edge detection, and feature extraction.	L1
3	Apply stereo vision concepts, depth estimation, and 3D reconstruction techniques for robotic applications.	L2
4	Understand the basics of robot programming, including low-level control, kinematics, and high-level decision-making.	L6
5	Understand the principles of machine vision, image acquisition, and the role of vision systems in manufacturing automation.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. David Vernon, Machine vision –Automated Visual Inspection and Robot Vision, Prentice Hall, 1991(Units: I - IV)
2. Alexander Hornberg, Handbook of Machine Vision, Wiley, 2006. (Unit V)

REFERENCE BOOKS:

1. Rafael C. Gonzales, Richard. E. Woods, Digital Image Processing, Pearson Education, 2008.
2. Alexander Hornberg, Handbook of Machine and Computer Vision, 2nd Edition, Wiley, 2017.

PROFESSIONAL ELECTIVE COURSE – I

THERMAL FLUIDS AND ELECTRONICS COOLING			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – V			
Course Code	: 23RA3507	Credits	: 02
Hours/Week	: 02	Total Hours	: 26
L-T-P-J	: 2-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Appreciate the importance of thermal management for the performance and reliability of electronic devices. 2. Identify how temperature impacts failure modes and component lifespan in electronic systems. 3. Utilize conduction, convection, and radiation principles in designing thermal management solutions 4. Evaluate and select appropriate cooling methods based on performance requirements and cost-effectiveness. 5. Apply simulations to optimize cooling strategies, predict temperature distributions, and evaluate thermal management effectiveness			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods that teachers can use to accelerate the attainment of the various course outcomes: • Lecture method means it includes not only traditional lecture method but different <i>types of teaching methods</i> that may be adopted to develop the course outcomes. • Interactive Teaching: Adopt Active learning that includes brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. • Show Video/animation films to explain the functioning of various concepts. • Encourage Collaborative (Group Learning) Learning in the class. • To make Critical thinking, ask at least three Higher-order Thinking questions in the class. • Adopt Problem-Based Learning, which fosters students' Analytical skills, and develops thinking skills such as evaluating, generalizing, and analysing information rather than simply recalling it. • Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them. • Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding. • Practical experimentation of material testing of different metals and alloys.			
UNIT – I			05 Hours
Introduction to Thermal Management Understanding the critical role of thermal management in electronics, its impact on performance, reliability, and overall system lifespan. Overview of economic and operational consequences of thermal issues. Temperature Effects on Failure Modes: Exploration of how temperature affects failure mechanisms like thermal stress, fatigue, electromigration, and material expansion in electronic components.			
UNIT – II			05 Hours
Conduction Cooling and Heat Sinks Study of materials and thermal interface materials (TIMs) used to enhance heat conduction in electronic systems, Heat Sink Design: Core principles of heat sink design, including material choice, geometry, and surface treatments. examination of advanced configurations like pin-fin and vapor chamber heat sinks. Convection Cooling: Overview of natural and forced convection cooling methods, focusing on fan selection, placement, and optimization for effective airflow management.			

UNIT – III	06 Hours
Liquid Cooling Techniques Introduction to liquid immersion cooling, its principles, and the selection of appropriate dielectric fluids for high-performance applications, Flow-Through Cooling for Circuit Card Assemblies (CCAs) Cold wall cooling and Cold Plates: Exploration of cold wall cooling and cold plate designs, their applications, and integration into electronic systems for enhanced heat dissipation.	
UNIT – IV	05 Hours
Advanced and Emerging Cooling Technologies Principles and applications of jet impingement and synthetic jet cooling, focusing on their use for localized, high-efficiency cooling. Thermoelectric (Solid-State) Coolers, Cooling Using Phase Change Materials (PCM): Use of phase change materials in thermal management, including selection criteria and integration techniques.	
UNIT – V	05 Hours
Micro/Mini Channel Cooling Applications of micro/mini channel cooling technologies in high-density and high-power electronics. Heat Pipes: Study of heat pipe principles, working fluids, and their integration into thermal management systems for efficient heat transfer.	

Couse Outcomes

Course Outcome (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the fundamental concepts of thermal management to assess their impact on the performance and reliability of electronic devices	L1
2	Design and Evaluate heat sinks with optimal material choice, geometry, and surface treatments, including advanced configurations like pin-fin and vapor chamber heat sinks	L1
3	Evaluate and Optimize different cooling methods, including heat sinks, liquid cooling, and advanced technologies like thermoelectric coolers and heat pipes, to enhance thermal performance	L2
4	Analyse micro/mini channel cooling technologies to manage heat dissipation in high-density and high-power electronic applications	L6
5	Simulate and predict the thermal behaviour of electronic systems using MATLAB and CFD tools to develop and refine cooling strategies	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	2	-	3	1	1	1	2	2	1	1	3	2	-
CO-2	3	2	3	-	3	1	1	1	2	2	1	1	3	3	-
CO-3	3	3	3	-	3	1	1	1	2	2	1	1	3	3	-
CO-4	3	3	3	-	3	1	1	1	2	2	1	1	3	2	-
CO-5	3	2	3	-	3	1	1	1	2	2	1	1	3	3	-

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

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

REFERENCE BOOKS:

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

E-Resources:

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

PATTERN RECOGNITION [As per Choice Based Credit System (CBCS) scheme]	
SEMESTER - V	
Course Code : 23RA3508	Credits : 02
Hours / Week : 02	Total Hours : 26
L-T-P-J : 2-0-0-0	CIE+SEE : 60+40 Marks
Course Objectives: This course will enable students to: • Understanding of pattern recognition principles, including feature extraction, classification, and clustering. • Explain statistical decision-making, Bayesian classification, and structural pattern recognition techniques. • Understanding of sequential data, pattern discovery, and applications in time-series analysis, speech recognition, and bioinformatics. • Introduce the fundamentals of dimensionality reduction. • Understanding of parameter estimation concepts in statistics, signal processing, and machine learning.	
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.	
UNIT - I	05 Hours
Basics of Probability, Random Processes and Linear Algebra Probability: Independence of events, conditional and joint probability, Bayes' theorem; Random Processes: Stationary and nonstationary processes, Expectation, Autocorrelation, Cross-Correlation, spectra; Linear Algebra: Inner product, outer product, inverses, eigen values, eigen vectors; Bayes Decision Theory. Bayes Decision Theory: Minimum-error-rate classification, Classifiers, Discriminant functions, Decision surfaces, Normal density and discriminant functions, discrete features.	
UNIT - II	05 Hours
Parameter Estimation Methods Maximum-Likelihood estimation: Gaussian case, Maximum a Posteriori estimation, Bayesian estimation: Gaussian case. Unsupervised learning and clustering: Criterion functions for clustering, Algorithms for clustering: K-Means, Hierarchical and other methods. Cluster validation, Gaussian mixture models, Expectation-Maximization method for parameter estimation, Maximum entropy estimation.	
UNIT - III	06 Hours
Sequential Pattern Recognition Hidden Markov Models (HMMs), Discrete HMMs; Continuous HMMs, Nonparametric techniques for density estimation: Parzen-window method. K-Nearest Neighbour method.	

UNIT – IV	05 Hours
Dimensionality Reduction Fisher discriminant analysis; Principal component analysis, Factor Analysis, Linear discriminant functions: Gradient descent procedures. Perceptron, Support vector machines.	
UNIT – V	05 Hours
Non-metric Methods for Pattern Classification Non-numeric data or nominal data, Decision trees: CART, Application(s): Face recognition - preprocessing, face detection algorithms, selection of representative patterns, classification algorithms, results and discussion.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the Fundamentals of Probability Theory.	L1
2	Extract meaningful features from data and apply dimensionality reduction techniques such as Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) to improve classification performance.	L1
3	Utilize Bayesian decision theory, Maximum Likelihood Estimation (MLE), and Hidden Markov Models (HMMs) for probabilistic pattern recognition.	L2
4	Understand the Need for Dimensionality Reduction.	L6
5	Define high-dimensional data and explain the importance of dimensionality reduction in mitigating issues like the "curse of dimensionality."	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001.
2. S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009.

REFERENCE BOOKS:

1. C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
2. P.A Devijver and J. Kittler, Pattern Recognition: A Statistical Approach, Prentice-Hall International, Englewood Cliffs, NJ, 1980.
3. K. Fukunaga, Introduction to Statistical Pattern Recognition, 2nd Ed. Academic Press, New York, 1990.

ADVANCED AI TECHNIQUES FOR ROBOTICS

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

SEMESTER – V

Subject Code	: 23RA3509	Credits	: 02
Hours / Week	: 02	Total Hours	: 26
L-T-P-J	: 2-0-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This Course will enable students to:

1. **Understand** the fundamental principles and techniques of artificial intelligence relevant to robotic systems.
2. **Explore** the integration of NLP techniques to enable human-robot interaction through voice and text-based communication.
3. **Explore** the differences between traditional programming and AI-driven approaches in robotics.
4. **Utilize** advanced AI techniques for object recognition, scene understanding, and sensor data processing.
5. **Understand** the concepts of reasoning.

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 analyze 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

Brief History of AI, Basic Content of Artificial Intelligence Research - Cognitive Modeling, Knowledge Representation, Automatic Reasoning, Machine Learning. Main Schools of Artificial Intelligence Research – Symbolism, Connectionism, Behaviorism. New Generation Artificial Intelligence, Artificial Intelligence Applications – Expert System, Data Mining, Natural Language Processing, Intelligent Robot, Pattern Recognition, Distributed Artificial Intelligence, Internet Intelligence, Game, AI for Science.

UNIT – II

05 Hours

Logic Foundation

Introduction, Logic Programming - Definitions of Logic Programming, Data Structure and Recursion in Prolog, SLD Resolution, Non-Logic Components: CUT. Closed World Assumption, Non-monotonic Logic, Default Logic, Circumscription Logic, Non-Monotonic Logic NML, Autoepistemic Logic, Truth Maintenance System, Situation Calculus - Many-Sorted Logic for Situation Calculus, Basic Action Theory in LR, Dynamic Description Logic - Description Logic, Syntax of Dynamic Description Logic (DDL), Semantics of Dynamic Description Logic.

UNIT - III	06 Hours
Deep Learning: Introduction, Human Brain Visual Mechanism, Autoencoder, Restricted Boltzmann Machine, Deep Belief Networks, Convolutional Neural Networks, Recurrent Neural Networks, Long Short-Term Memory, Neural Machine Translation - Introduction, Model Architecture, Quantized Inference.	
UNIT - IV	05 Hours
Reinforcement Learning: Introduction, Reinforcement Learning Model, Dynamic Programming, Monte Carlo Methods, Temporal-Difference Learning, Q-Learning, Function Approximation, Reinforcement Learning Applications - RoboCup, Multi-Armed Gambling Machine.	
UNIT - V	05 Hours
Transfer Learning: Introduction - History, Important Concepts, Similarity Measure, Classifications, Negative Transfer. Inductive Transfer Learning, Transductive Transfer Learning, Model-Based Transfer Learning - Bayesian Models, Gaussian Process (GP). Deep Transfer Learning, Heterogeneous Transfer Learning, Multi-task Transfer Learning, Domain Adaptation Transfer Learning.	

Course Outcomes

Course Outcome (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the core concepts of Artificial Intelligence (AI) and their applications in robotics.	L2 & L3
2	Differentiate between traditional robotic programming and AI-driven robotic systems.	L2 & L3
3	Understand the role of machine learning (ML) techniques, such as supervised, unsupervised, and reinforcement learning, in robotics.	L2 & L3
4	Enable human-robot interaction through language understanding, speech recognition, and command execution.	L2 & L3
5	Develop conversational AI for intuitive communication with robots.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

Textbooks:

1. Zhongzhi Shi, 'Advanced Artificial Intelligence', 3rd Edition, World Scientific Publishing Co. Pte. Ltd.
2. Shia, H., Govers, F. X., "Artificial Intelligence for Robotics: Build Intelligent Robots Using Deep Learning and Reinforcement Learning," Packt Publishing, 2019.

Reference Books:

1. Francis X. Govers, Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques, Second edition, Packt Publishing.
2. Zeng, A., Song, J., Xiao, J., "Advanced Robotics and Intelligent Systems," Springer, 2020.

HEALTHCARE ROBOTICS

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

SEMESTER – V

Course Code	: 23AIR3510	Credits	: 02
Hours / Week	: 02	Total Hours	: 26
L-T-P-J	: 2-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Understand the fundamental concepts of healthcare robot. 2. Understand the fundamental concepts of Rehabilitation and soft robots for healthcare. 3. Explore the concepts of soft wrist rehabilitation robot. 4. Explore the Robotics for Rehabilitation and Sensors and Motion Systems. 5. Explore the Gait Capture Systems for health care application.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			05 Hours
Healthcare requirements Soft robots for healthcare applications, Definition of soft robots, Examples of soft robots for healthcare, Motivation of soft robots for healthcare, Critical issues in developing soft robots for healthcare, Acceptance of healthcare robots, soft actuators, Modelling and control of soft actuators			
UNIT – II			05 Hours
Rehabilitation robots for healthcare Upper-limb rehabilitation exoskeletons, Gait rehabilitation exoskeletons, Ankle rehabilitation robots, soft robots for healthcare, soft robots for various applications, soft robots for healthcare			
UNIT – III			06 Hours
Soft wrist rehabilitation robot Introduction, Device design, Force and torque distribution, Control strategies, Pneumatic setup, Model-based control, Feedback-based control, Design comparison, System integration and experiments, Software architecture			
UNIT – IV			05 Hours
Robotics for Rehabilitation A State of the Art: Introduction, Upper Limb Exoskeleton Rehabilitation Robots, Lower Limb Exoskeleton Rehabilitation Robots. Sensors and Motion Systems: Introduction, Sensors Are Becoming an Inherent Part of Our Routine Life, Use of Sensors in Healthcare and Wellness Sector, Role of Motion Sensors or Mobility Aids in Medical Field, Types of Mobility Aids, Walkers, Rollators, Wheelchairs, Electric Wheelchairs Scooter, Kart Bot, People Getting Benefitted from Mobility Aids, Hoverboards as an E-Mobility Device Used for Commuting, Maneuvering, Transportation, for Quick First Aid and Delivery of Medical Supplies, Carrying Patients and Most Importantly as Portable Wheelchairs, Hoverboards Are the Futuristic E-Mobility Devices; Precisely We Can Say Future of Mobility, Decoding Future for Mankind			

UNIT - V	05 Hours
Gait Capture Systems Introduction, Motion Capturing Systems, Vicon, Motion Analysis, Optitrack, Qualisys, Codamotion, The Proposed System, Data Acquisition Software, Development Platform, Software Features, Sensor Data Reception and Processing, Data Deployment and .txt File Generation	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's TaxonomyLevel
At the end of the course the student will be able to:		
1	Understand the fundamental concepts of healthcare robot.	L2
2	Understand the fundamental concepts of Rehabilitation and soft robots for healthcare.	L2
3	Explore the concepts of soft wrist rehabilitation robot.	L2 & L3
4	Explore the Robotics for Rehabilitation and Sensors and Motion Systems.	L2
5	Explore the Gait Capture Systems for health care application.	L2 & L3

Mapping Levels of COs to POs / PSOs

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
CO-1	1	1	1	1	1	-	-	-	-	-	-	1	1	1	1
CO-2	1	1	1	1	1	-	-	-	-	-	-	1	1	1	1
CO-3	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO-4	1	1	1	1	1	-	-	-	-	-	-	1	1	1	1
CO-5	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

- S. Xie, M. Zhang and W. Meng, "Soft Robots for Healthcare Applications Design, modelling, and control", 2 Published by The Institution of Engineering and Technology, London, United Kingdom, 2017.
- Manuel Cardona, Vijender Kumar Solanki, Cecilia E. García Cena, "Exoskeleton Robots for Rehabilitation and Healthcare Devices", Springer 2020.

REFERENCE BOOKS:

- Olfa Boubaker, "Medical and Healthcare Robotics New Paradigms and Recent Advances", Elsevier, 2023.

VI-Semester Syllabus

GENERATIVE AI [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Course Code	: 23RA3601	Credits	: 04
Hours / Week	: 05	Total Hours	: 39 + 26
L-T-P-J	: 3-0-2-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Understand the Fundamentals: Students will gain a comprehensive understanding of the foundational concepts of generative AI, including the differences between generative and discriminative models, and the various types of generative models such as GANs, VAEs, and diffusion models. 2. Implement Text-to-Image and Text-to-Video Generation: Students will learn to bridge the gap between text and visual data by implementing text-to-image and text-to-video generation techniques, utilizing pre-trained models and fine-tuning them for specific applications. 3. Explore Audio Processing Techniques: Students will explore the challenges and methodologies involved in audio data processing, including the implementation of AI-driven text and audio conversion models, and understand architectures like CTC and Seq2Seq. 4. Analyze Large Language Models: Students will analyze the phases of training and adoption of large language models (LLMs), including their architecture, types, and applications in natural language processing tasks such as sentiment analysis and text summarization. 5. Apply Advanced Prompting Techniques: Students will develop skills in advanced prompting techniques for LLMs, including few-shot prompting and chain-of-thought reasoning, and will engage in practical case studies to fine-tune LLMs for specific tasks, enhancing their understanding of model efficiency and performance.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			08 Hours
Unveiling the Magic of Generative AI The Genesis of Generative AI, Milestones Along the Way, Fundamentals of Generative Models, Neural Networks: The Backbone of Generative AI, Understanding the Difference: Generative vs. Discriminative Models, Understanding the Core: Types and Techniques, Diffusion Models, Generative Adversarial Networks, Variational Autoencoders, Restricted Boltzmann Machines, Pixel Recurrent Neural Networks, Generative Models in Society and Technology, Real-World Applications and Advantages of Generative AI, Ethical and Technical Challenges of Generative AI, Impact of Generative Models in Data Science, The Diverse Domains of Generative AI, Visuals: From Pixel to Palette, Audio: Symphonies of AI, Text: Weaving Words into Worlds, The Future of Generative AI: A Symphony of Possibilities			
UNIT – II			08 Hours
Text-to-Image Generation Introduction, Bridging the Gap Between Text and Image Data, Understanding the Fundamentals of Image Data, Correlation Between Image and Text Data Using CLIP Model, Diffusion Model, Text-to-Image Generation, Using a Pre-trained Model, Fine-Tuning Text-to-Image Models, Conclusion, From Script to Screen: Unveiling Text-to-Video Generation, Introduction, Understanding Video Data, Challenges in Working with Video Data, The Synergy of Video and Textual Data, Hands-On: Demonstrating a Pre-Trained			

Model, Step 1: Installing Libraries, Step 2: Model Inference, Fine-Tuning for Custom Applications, Step 1: Installing Libraries, Step 2: Data Loading and Preprocessing, Step 3: Model Training (Fine-Tuning), Step 4: Model Inference, Conclusion.	
UNIT – III	08 Hours
Bridging Text and Audio in Generative AI Brief History, Fundamentals and Challenges, Understanding Audio Data, Challenges in Working with Audio Data, Mitigating Challenges in Audio Data Processing, Bridging Text and Audio: The CLAP Model Implementation, Step 1: Installing Libraries and Data Loading, Step 2: Model Inference, Understanding AI-Driven Text and Audio Conversion Models, Understanding CTC Architectures, Understanding Seq2Seq Architectures, Implementation AI-Driven Text and Audio Conversion Models, Speech to Text, Text to Speech, Conclusion,	
UNIT – IV	8 Hours
Large Language Models Introduction, Phases of Training and Adoption of Large Language Models, Types of Language Transformers Models, Encoder Models, Fine-Tuning BERT, Decoder-Only Models (Generative Pre-trained Transformer), Encoder-Decoder Models, A Glimpse into the LLM Horizon: Where Do We Go from Here? Summary.	
UNIT – V	7 Hours
Generative Large Language Models Introduction, NLP Tasks Using LLMs, Sentiment Analysis, Entity Extraction, Topic Modeling, Natural Language Generation Tasks Using LLMs, Creative Writing, Text Summarization, Dialogue Generation, Advanced Prompting Techniques, Few-Shot Prompting, Chain-of-Thought, prompting vs Fine-Tuning, Fine-Tuning LLMs, Case Study: Fine-Tuning an LLM for Sentiment Analysis, Parameter Efficient Fine-Tuning, Fine-Tuning LLM for Question Answering, Summary	
Generative AI Lab Programs Program 1: Write a complete program in Python /MATLAB to perform Text Generation with Markov Chains Program 2: Write a complete program in Python /MATLAB to perform Basic GAN Implementation (MNIST) Program 3: Write a complete program in Python /MATLAB to perform Text-to-Image Generation with Stable Diffusion (Simplified) Program 4: Write a complete program in Python /MATLAB to perform Variational Autoencoder (VAE) for Image Generation Program 5: Write a complete program in Python /MATLAB to perform Style Transfer with Neural Networks Program 6: Write a complete program in Python /MATLAB to perform Chatbot with Transformers Program 7: Write a complete program in Python /MATLAB to perform Music Generation with LSTM Program 8: Write a complete program in Python /MATLAB to perform Image Captioning with CNN-RNN Program 9: Write a complete program in Python /MATLAB to perform Text Summarization with Transformers Program 10: Write a complete program in Python/MATLAB to perform Video Generation with 3D Convolutional Neural Networks (3D CNNs) Program 11: Write a complete program in Python/MATLAB to perform Emotion Recognition and Sentiment Analysis with Facial Expression Recognition using Deep Learning	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the principles of generative models and their distinction from discriminative models.	L1
2	Explain the architecture and working principles of Large Language Models (LLMs).	L1
3	Explain the core concepts of generative models and their distinction from traditional NLP techniques.	L2
4	Understand the fundamentals of Text-to-Image Generation.	L6
5	Explain the principles of generative AI for text and audio synthesis.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. T. Karras, S. Laine, and T. Aila, "Advanced Generative Adversarial Networks: Principles and Applications", Published by Springer, Cham, Switzerland, 2021.
2. A. Borji, "A Comprehensive Guide to Generative AI: From GANs to Diffusion Models", Published by Morgan & Claypool Publishers, San Rafael, California, United States, 2023.

REFERENCE BOOKS:

1. J. Leskovec, A. Rajpurkar, and P. Liang, "Foundation Models and Generative AI: Theory, Practice, and Challenges", Published by Cambridge University Press, Cambridge, United Kingdom, 2024.
2. Y. Bengio, I. Goodfellow, and A. Courville, "Deep Learning and Generative Models", Published by MIT Press, Cambridge, Massachusetts, United States, 2023.

INNOVATION AND ENTREPRENEURSHIP

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

SEMESTER – VI

Subject Code	: 23RA3602	Credits	: 02
Hours / Week	: 02	Total Hours	: 26
L-T-P-J	: 2-0-0-0	CIE+SEE	: 60+40 Marks

Course objectives:

The objectives of this course are to:

1. **Explain** fundamentals management functions of a manager. Also explain planning and decision-making processes.
2. **Explain** the organizational structure, staffing and leadership process.
3. **Describe** the understanding of motivation and different control systems in management.
4. **Explain** understanding of Entrepreneurships and Entrepreneurship development process.
5. **Illustrate** Small Scale Industries, various types of supporting agencies and financing available for an entrepreneur.
6. **Summarize** the preparation of project report, need significance of report. Also to explain about industrial ownership.

Teaching-Learning Process (General Instructions)

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

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

UNIT – I

05 Hours

Management

Introduction - Meaning - nature and characteristics of Management, Scope and Functional areas of management - Management as art or science, art or profession - Management & Administration - Roles of Management, Levels of Management, Development of Management Thought - early management approaches - Modern management approaches. Planning: Nature, importance and purpose of planning process objectives - Types of plans (meaning only) - Decision making, Importance of planning - steps in planning & planning premises - Hierarchy of plans.

UNIT – II

05 Hours

Organizing and staffing

Nature and purpose of organization, Principles of organization – Types of organization-Departmentation Committees-Centralization Vs Decentralization of authority and responsibility - Span of control - MBO and MBE (Meaning only) Nature and importance of staffing- Process of Selection & Recruitment (in brief). Directing: Meaning and nature of directing Leadership styles, Motivation, Theories, Communication - Meaning and importance - coordination, meaning and importance and Techniques of coordination.

UNIT – III	05 Hours
Entrepreneur: Meaning of Entrepreneur; Evolution of the Concept; Functions of an Entrepreneur, Types of Entrepreneurs, Entrepreneur - an emerging. Class. Concept of Entrepreneurship - Evolution of Entrepreneurship, Development of Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Entrepreneurship in India; Entrepreneurship - its Barriers.	
UNIT – IV	06 Hours
Small scale industries: Definition; Characteristics; Need and rationale; Objectives; Scope; role of SSI in Economic Development. Advantages of SSI, Steps to start and SSI - Government policy towards SSI; Different Policies of SSI; Government Support for SSI during 5-year plans. Impact of Liberalization, Privatization, Globalization on SSI Effect of WTO/GA TT Supporting Agencies of Government for SSI, Meaning, Nature of support; Objectives; Functions; Types of Help; Ancillary Industry and Tiny Industry (Definition Only).	
UNIT – V	05 Hours
Preparation of project: Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; formulation; Guidelines by Planning Commission for Project report; Network Analysis; Errors of Project Report; Project Appraisal. Identification of Business Opportunities. Market Feasibility Study: Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. Industrial ownership: Definition and meaning of Partnership, Characteristics of Partnership, Kinds of Partners, Partnership Agreement or Partnership Deed, Registration of Partnership Firm, Rights, Duties and Liabilities of Partners, Advantages and Disadvantages of Partnership, Sole proprietorship, Features, Scope Advantages and Disadvantages of Sole Proprietorship.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Gain a comprehensive understanding Management Principles.	L2 & L3
2	Proficiency in process of planning and also grasp the role of decision-making in planning.	L2 & L3
3	Understand the principles of organization structure and gain knowledge of staffing processes, including recruitment and selection.	L2 & L3
4	Acquire a clear understanding of the entrepreneurial process, the functions and types of entrepreneurs.	L2 & L3
5	Learn the key elements of project preparation, including project identification, selection, report formulation and develop an understanding of various business ownership structures.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	-	-	3	2	-	-	-	-	-	-	3	3	3
CO-2	-	-	3	3	-	3	3	-	-	-	-	-	3	3	3
CO-3	-	-	3	-	3	-	-	-	3	-	3	3	3	3	3
CO-4	-	3	3	3	-	-	3	-	-	3	-	-	3	3	3
CO-5	3	-	-	3	3	-	-	-	3	-	-	3	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

Text Books:

1. Principles of Management – P. C. Tripathi, P.N. Reddy – Tata McGraw Hill.
2. Dynamics of Entrepreneurial Development & Management-Vasant Desai, Himalaya Publishing House.
3. Entrepreneurship Development – Poornima. M. Charantimath, Small Business Enterprises Pearson Education - 2006 (2 & 4).

Reference Books:

1. Management Fundamentals - Concepts, Application, Skill Development – Robers Lusier, Thomson.
2. Entrepreneurship Development - S. S. Khanka, S. Chand & Co. New Delhi.
3. Management - Stephen Robbins, Pearson Education/PHI - 17thEdition, 2003.

HUMANOID ROBOTS

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

(Lab Integrated Core Course)

SEMESTER – VI

Course Code	: 23RA3603	Credits	: 04
Hours / Week	: 05	Total Hours	: 39+26
L-T-P-J	: 3-0-2-0	CIE+SEE	: 60+40 Marks

Course Objectives:

1. **Explore** the fundamental principles and applications of humanoid robotics, emphasizing the design, development, and integration of mechanical, electrical, and computational subsystems.
2. **Investigate** advanced techniques in kinematics, dynamics, control systems, and artificial intelligence to enable humanoid robots to perform complex tasks in real-world scenarios.

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** along with traditional lecture method, different type of teaching methods may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I	08 Hours
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Introduction to Humanoid Robotics

Introduction to Robotics and Overview of Humanoid Robots, History and Evolution of Humanoid Robots, Key Features and Differences Between Humanoid Robots and Other Robots. Ethical and Societal Impacts of Humanoid Robots. Applications of Humanoid Robots in: Healthcare. Industrial Automation. Education and Research. Entertainment and Service Industries. Challenges in Building Humanoid Robots: Cost, Complexity, and Energy Efficiency.

UNIT – II	08 Hours
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Anatomy of a Humanoid Robot

Structural Design of Humanoid Robots: Limbs, Torso, and Head Design. Degrees of Freedom (DoF) in Humanoid Robots. Actuators: Types: Electric Motors, Hydraulic Systems, Pneumatic Systems. Actuator Selection for Humanoid Robots. Sensors: Vision Sensors: Cameras and Depth Sensors. Tactile Sensors: Skin-like Sensors for Touch and Pressure. Proprioception Sensors: Joint Position and Force Sensing. Power and Energy Systems: Batteries and Alternative Power Sources. Energy Optimization Techniques. Embedded Systems and Communication Interfaces.

UNIT – III	08 Hours
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Kinematics and Dynamics of Humanoid Robots

Fundamentals of Kinematics: Forward and Inverse Kinematics for Limbs. Denavit-Hartenberg (D-H) Parameterization. Dynamics of Humanoid Robots: Newton-Euler and Lagrangian Methods. Dynamic Modeling of Biped Robots. Stability and Balance Control: Zero Moment Point (ZMP) Theory. Center of Gravity and Stability Margin. Gait and Trajectory Planning: Types of Gaits (Static and Dynamic Gaits). Trajectory Generation for Walking, Running, and Climbing. Case Studies: Analysis of Gait in Popular Humanoid Robots.

UNIT – IV		08 Hours
Control Systems for Humanoid Robots		
Basics of Control Systems: Open-loop and Closed-loop Control. PID Controllers and Their Applications in Humanoids. Advanced Control Techniques: Adaptive Control and Learning-based Control. Nonlinear Control Techniques. Motion Control Strategies: Joint Space Control. Task Space Control. Redundancy Resolution in Humanoid Motion. Real-time Control: Control of Dynamic Movements like Running and Jumping. Latency and Feedback Challenges. Sensors and Actuator Integration in Control. PID Controllers and Their Applications in Humanoids. Advanced Control Techniques: Adaptive Control and Learning-based Control. Nonlinear Control Techniques. Motion Control Strategies: Joint Space Control. Task Space Control. Redundancy Resolution in Humanoid Motion. Real-time Control: Control of Dynamic Movements like Running and Jumping. Latency and Feedback Challenges. Sensors and Actuator Integration in Control.		
UNIT – V		07 Hours
Advanced Topics and Applications		
Artificial Intelligence (AI) in Humanoid Robotics: Role of AI in Perception, Planning, and Decision-Making. Machine Learning for Real-Time Adaptation. Human-Robot Interaction (HRI): Communication Methods (Voice, Gesture, and Facial Recognition). Safety and Trust in HRI. Applications of Humanoid Robots: Assistive Robots for Healthcare and Rehabilitation. Service Robots in Hospitality and Retail. Research Robots for Space Exploration. Case Studies: ASIMO, Atlas, Sophia, NAO, and Pepper Robots. Future Trends: Soft Robotics in Humanoids. Autonomous Learning and Cloud Robotics. Challenges and Future Directions.		
LABORATORY EXPERIMENTS / PROGRAMS		Total Contact Hours: 26
1. Introduction to Robotic Simulation Tools: Description: Set up and explore a robotic simulation environment such as MATLAB, Gazebo, or ROS. Simulate basic robotic movements like forward motion, turning, and obstacle avoidance. 2. Kinematics of Robotic Arms: Description: Implement forward and inverse kinematics for a 2-DOF or 3-DOF robotic arm. Simulate the arm's motion to reach a desired target position. 3. Path Planning and Trajectory Generation: Description: Design a simple path-planning algorithm using Dijkstra's or A* for navigating a robotic agent in a 2D environment. Generate a smooth trajectory for the robot to follow. 4. PID Control Implementation: Description: Implement a PID controller to control the speed of a DC motor or a simulated robotic joint. Tune the parameters for optimal performance and observe the system's response. 5. Obstacle Detection and Avoidance: Description: Use sensors (e.g., ultrasonic or simulated LiDAR) to detect obstacles and program the robot to avoid them while moving towards a target location. 6. Human-Robot Interaction Basics: Description: Create a basic human-robot interaction interface using voice commands or gesture recognition. Program the robot to respond to simple inputs like "move forward," "stop," or "turn left."		
<i>Number of experiments may be increased as per requirement by the course coordinator.</i>		

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Levels
At the end of the course the student will be able to:		
1	Define the key features, applications, and challenges of humanoid robots and list their historical developments.	L1
2	Describe the anatomy of humanoid robots, including sensors, actuators, and power systems, and explain their integration in robotic systems.	L2
3	Apply kinematic and dynamic principles to model and solve problems related to humanoid robot stability, balance, and gait generation.	L3
4	Analyze control systems, including PID and nonlinear controllers, to evaluate their effectiveness in achieving precise humanoid robot movements.	L4
5	Evaluate advanced applications of humanoid robotics, including human-robot interaction and AI integration, and design solutions for real-world challenges in healthcare, industry, and research.	L5

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	-	-		-	-	-	-	-	-	3	3	-	-
CO-2	3	3	-	-	2	-	-	-	-	-	-	2	3	-	-
CO-3	3	2	3	3	-	-	-	-	-	-	-	1	3	3	-
CO-4	3	3	2	3	-	-	-	-	-	-	-	1	3	3	-
CO-5	2	3	3	-	2	-	-	-	-	-	-	-	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

- Shuuji Kajita, Hirohisa Hirukawa, Kensuke Harada, Kazuhito Yokoi, "Introduction to Humanoid Robotics," Springer, ISBN: 978-3642545351, 2014.
- Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, "Robotics: Modelling, Planning and Control," Springer, ISBN: 978-1846286414, 2010.

REFERENCE BOOKS:

- Mark W. Spong, Seth Hutchinson, M. Vidyasagar, "Robot Modeling and Control," Wiley, ISBN: 978-0471649908, 2005.
- Kevin M. Lynch, Frank C. Park, "Modern Robotics: Mechanics, Planning, and Control," Cambridge University Press, ISBN: 978-1107156302, 2017.

OPEN ELECTIVES - I

AGILE METHODOLOGY FOR PROJECT DEVELOPMENT			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Course Code	: 23RA3605	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to:			
1. Understand Agile Principles: By the end of the course, students will be able to explain the core principles and values of Agile methodologies and how they differ from traditional software development approaches. 2. Apply Scrum Framework: Students will be able to effectively implement the Scrum framework, including defining roles, conducting ceremonies, and managing artifacts within a team setting. 3. Utilize Kanban for Workflow Management: Students will learn to apply Kanban principles to visualize and optimize workflow, manage work-in-progress limits, and enhance team collaboration. 4. Conduct Agile Testing: Students will be able to design and execute various types of Agile testing, including automated testing strategies, to ensure software quality throughout the development process. 5. Manage Agile Projects: By the end of the course, students will be able to plan, execute, and monitor Agile projects, utilizing tools and techniques for effective project management and team dynamics. 6. Evaluate Agile Practices: Students will critically assess the effectiveness of different Agile methodologies and practices in real-world scenarios, enabling them to recommend appropriate approaches based on project needs			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			08 Hours
Introduction to Agile Introduction to Software Engineering, SDLC, Software process models- waterfall, V model, Iterative model, Spiral model; Introduction to Agile: Agile versus traditional method comparisons and process tailoring; Introduction to Agile, Various Agile methodologies -Scrum, XP, Lean, and Kanban, Agile Manifesto.			
UNIT – II			08 Hours
Scrum and Sprint Scrum: Scrum process, roles - Product Owner, Scrum Master, Team, Release manager, Project Manager, product manager, architect, events, and artifacts; Product Inception: Product vision, stakeholders, initial backlog creation; Agile Requirements – User personas, story mapping, user stories, 3Cs, INVEST, acceptance criteria, sprints, requirements, product backlog and backlog grooming; Test First Development; Pair Programming and Code reviews.			

UNIT - III	08 Hours
Agile Project Management Sprint Planning, Sprint Reviews, Sprint Retrospectives, Sprint Planning - Agile release and iteration (sprint) planning, Develop Epics and Stories, Estimating Stories, Prioritizing Stories (WSJF technique from SAFE), Iterations/Sprints Overview. Velocity Determination, Iteration Planning Meeting, Iteration, Planning Guidelines, Development, Testing, Daily Stand-up Meetings, Progress Tracking, Velocity Tracking, Monitoring and Controlling: Burn down Charts, Inspect & Adapt (Fishbone Model), Agile Release Train.	
UNIT - IV	8 Hours
Agile Testing: Testing: Functionality Testing, UI Testing (JUnit, Sonar), Performance Testing, Security Testing, A/ B testing; Agile Testing: Principles of agile testers; The agile testing quadrants, Agile automation, Test automation pyramid; Test Automation Tools - Selenium, Traceability matrix.	
UNIT - V	7 Hours
Agile Software Development Case Studies Case Study 1: Agile Transformation in a Financial Services Company. Case Study 2: Implementing Kanban in a Marketing Agency Case Study 3: Enhancing Collaboration through Scrum in a Healthcare Organization Case Study 4: Scaling Agile Practices in a Large Retail Company	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the Fundamentals of Agile Methodology.	L1
2	Understand and implement popular Agile frameworks such as Scrum, Kanban, Lean, and Extreme Programming (XP).	L1
3	Develop Agile project roadmaps, backlogs, and sprint planning strategies.	L2
4	Identify and mitigate risks using Agile risk management techniques.	L6
5	Explore Advanced Topics and Trends in Agile Development	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3
3: Substantial (High)				2: Moderate (Medium)				1: Poor (Low)							

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Methodology for the Design of Agile Product Development Networks, Riesener, Michael; Rebentisch, Eric; Doelle, Christian; Kuhn, Maximilian; Brockmann, Soeren, 2019, Elsevier.
2. Roman Pichler – *Agile Product Management with Scrum: Creating Products that Customers Love*, Addison-Wesley, 2010.

REFERENCE BOOKS:

1. Agile Product Development: How to Design Innovative Products That Create Customer Value, Tathagat Varma, Springer Nature, 1st ed. Edition, Apress.
2. Donald G. Reinertsen – *The Principles of Product Development Flow: Second Generation Lean Product Development*, Celeritas Publishing, 2009. (Bridges Agile & Lean principles.)

PRODUCT ENGINEERING & ENTREPRENEURSHIP

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

SEMESTER – VI

Course Code : 23RA3606	Credits : 03
Hours / Week : 03	Total Hours : 39
L-T-P-J : 3-0-0-0	CIE+SEE : 60+40 Marks

Course Objectives:

This course will enable students to:

1. **Understand** the foundational concepts of cognitive architecture, including its significance in both cognitive science and artificial intelligence.
2. **Analyze** various cognitive architectures, identifying their components and evaluating their effectiveness in simulating human cognitive processes.
3. **Design** a basic cognitive architecture model that incorporates principles of cognitive science, demonstrating the ability to create systems that mimic specific cognitive functions.
4. **Evaluate** the ethical implications and societal impacts of cognitive architectures, fostering a responsible approach to the development of intelligent systems.
5. **Collaborate** effectively in team projects, showcasing communication and teamwork skills while working on cognitive architecture design and evaluation tasks.

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** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I

08 Hours

Introduction

Characteristics of successful product development, design and development of products, duration, and cost of product development, the challenges of product development. Development Processes and Organizations: Generic development process, concept development: the frontend process, adopting the generic product development process, the AMF development process, product development organizations, the AMF organization.

UNIT – II

08 Hours

Product planning

Product planning process, identify opportunities, evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process Identifying customer needs: Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process.

UNIT – III

08 Hours

Concept Generation

Activities of concept generation, need for systems level thinking, TRIZ and its comparison with brainstorming and lateral thinking, TRIZ tools Ideality and IFR, problem formulation and functional analysis, use of 40 principles to solve contradiction, use of S-curves and technology evolution trends. Concept selection: Overview of methodology, concept screening, and concept scoring, Pugh matrix and its application. Concept testing: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process, Failure Mode Effect Analysis (DFMEA and PFMEA).

UNIT – IV	8 Hours
Product Architecture implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Industrial design: Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design. Design for X (DFX): Design for manufacturing: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors, design for assembly, service and quality.	
UNIT – V	7 Hours
Prototyping Prototyping basics, principles of prototyping, technologies, planning for prototypes Product development economics: Elements of economic analysis, base case financial mode, sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Articulate the key principles and theories of cognitive architecture, demonstrating an understanding of its relevance to cognitive science and artificial intelligence.	L1
2	Evaluate and compare different cognitive architectures, assessing their strengths and weaknesses in simulating human cognitive processes.	L1
3	Design a functional cognitive architecture model that incorporates cognitive science principles, showcasing the ability to create systems that replicate specific cognitive functions.	L2
4	Critically analyze the ethical implications and societal impacts of cognitive architectures, promoting responsible practices in the development of intelligent systems.	L6
5	Collaborate effectively in team settings, demonstrating strong communication and teamwork skills while working on cognitive architecture projects and evaluations	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. A K Chitale and R C Gupta, Product Design and Manufacturing, 6th Edition, PHI, New Delhi, 2003.
2. Karl.T.Ulrich and Steven D Eppinger Irwin, Product Design and Development, 5th Edition, McGraw-Hill, 2011.

REFERENCE BOOKS:

1. George E Deiter, Engineering Design, 5th Edition, McGraw-Hill , 2012 .
2. Boothroyd G, Dewhurst P and Knight W, Product Design for Manufacture and Assembly, 2nd Edition, Marcel Dekker, New York, 2002.
3. G Altshuller, H Altov, Lev Shulyak, And Suddenly the Inventor Appeared: TRIZ, The theory of Inventive Problem Solving, Technical Innovation Centre, 2nd Edition, May 1996.
4. Vladimir Petrov, Theory of Inventive Problem Solving, Level 1, Springer Series, 2019, ISBN: 978-3-030-04253-0

PROFESSIONAL ELECTIVE COURSE -II

Robotic Manipulation and Grasping [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER - VI			
Course Code	: 23RA3607	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Understand the fundamental concepts of automation and robotics. 2. Explore the concept of manipulation analysis and robot programming. 3. Analyse the fundamentals of the mechanics of grasp. 4. Explore the concept of sensors and methods for the evaluation of grasping. 5. Analyse the gripper mechanisms and stiffness analysis for grasping tasks.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT - I			07 Hours
Introduction to Automation and Robotics Automatic Systems and Robots, Evolution and Applications of Robots, Examples and Technical Characteristics of Robots, Evaluation of a Robotization.			
UNIT - II			08 Hours
Analysis of Manipulations Decomposition of Manipulative Actions, A Procedure for Analyzing Manipulation Tasks, Programming for Robots Programming Language for Robots: VAL-II, ACL, Education Practices, Industrial Applications.			
UNIT - III			08 Hours
Fundamentals of the Mechanics of Grasp A Short Account of History of Grasping Devices, Gripping Devices and Their Characteristics, A Mechatronic Analysis for Two-Finger Grippers, Design Parameters and Operation Requirements for Grippers, Configurations and Phases of Two-Finger Grasp, Model and Analysis of Two-Finger Grasp, Impacts in Grasping.			
UNIT - IV			08 Hours
Sensors and Methods for the Evaluation of Grasping Sensor Modalities, Contactless Sensors, Contact Sensors, Commercial Tactile Sensors, Resistive Sensors, QTC Sensors, Optical Sensors, Grasp Evaluation from Vision, Grasp Synthesis from Visual Input, Quality Metrics for Hand Configurations, Grasp Evaluation Combining Vision, Tactile, and Force Torque			
UNIT - V			08 Hours

Mechanisms for Grippers: Modeling Gripper Mechanisms, An Evaluation of Gripping Mechanisms, Designing Two-Finger Grippers, An Optimum Design Procedure for Gripping Mechanisms, Electropneumatic Actuation and Grasping Force Control, Fundamentals on Multi-finger Grasp and Articulated Fingers, Underactuated Finger Mechanisms, LARM Hand. Stiffness Analysis for Grasping Tasks: Stiffness Modelling and Analysis, Numerical Computation of Stiffness Performance, Cases of Study for Stiffness Modelling and Analysis- 6R Serial Manipulator, 3 DOF Parallel Manipulator, Two-Finger Milli-Gripper, Experimental Determination of Stiffness Performance- CaPaMan 2bis.

Course Outcomes

Course Outcome (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the fundamental concepts of automation and robotics.	L2
2	Explore the concept of manipulation analysis and robot programming.	L2 & L3
3	Analyze the fundamentals of the mechanics of grasp.	L2 & L3
4	Explore the concept of sensors and methods for the evaluation of grasping.	L2 & L3
5	Analyze the gripper mechanisms and stiffness analysis for grasping tasks.	L2 & L3

Mapping Levels of COs to POs / PSOs

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
CO-1	1	1	1	1	1	-	-	-	-	-	-	1	1	1	1
CO-2	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO-3	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO-4	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO-5	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Marco Ceccarelli, "Fundamentals of Mechanics of Robotic Manipulation", Second Edition, Springer, 2022.
2. Giuseppe Carbone, "Grasping in Robotics", Springer 2013.

REFERENCE BOOKS:

1. Matthew T. Mason, "Mechanics of Robotic Manipulation", A Bradford Book.
2. M. R. Cutkosky, "Robotic Grasping and Fine Manipulation", Springer, Cham,

HEURISTIC ALGORITHMS FOR GLOBAL OPTIMIZATION [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VI			
Course Code	:	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Understand and apply the fundamental concepts of heuristic algorithms and their role in global optimization. 2. Analyze and compare various heuristic optimization techniques, including genetic algorithms, particle swarm optimization, and chaotic algorithms. 3. Implement selected heuristic algorithms in programming environments to solve complex optimization problems. 4. Evaluate the effectiveness of different heuristic approaches through practical case studies and real-world applications. 5. Develop critical thinking skills to adapt and modify existing algorithms for specific optimization challenges. 6. Communicate findings effectively through presentations and written reports, demonstrating a clear understanding of the optimization processes and results.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
MODULE- I			08 Hours
Heuristic Algorithms for Global Optimization Introduction to Optimization Introduction Traditional Optimization and Meta-heuristic Optimization Chaotically Enhanced Meta-Heuristic Algorithms Chaos Embedded Meta-Heuristic Algorithms for Optimal Design and Goals.			
MODULE- II			08 Hours
Chaotic Maps and Meta-heuristic Algorithms Introduction, Chaotic Systems Scientific History of Chaos Theory Characteristics of Chaotic System Bifurcation on Chaotic System Attractor on Chaotic System Introduction to Chaos Maps and Forming Chaos Series Logistic Map Tent Map Gauss Map Liebovitch Map Chebyshev Map Sinusoidal Map Piecewise Map Lorenz Attractor System Chaos Series and Alternative Scenarios Meta-Heuristic Algorithms and Chaos Map.			
MODULE- III			08 Hours
Chaotic Cyclical Parthenogenesis Algorithm Introduction Standard Cyclical Parthenogenesis Algorithm (CPA) Basic Steps of Cyclical Parthenogenesis Algorithm Chaos Enhanced Cyclical Parthenogenesis Algorithm (CCPA) Constructive Role of Chaos Functions in Sensitivity Analysis Truss Weight Optimization with Static Constraints Formulation of the Structural Optimization Problems Introduction of Selected Chaos Map Numerical Examples of Optimal Truss Design Truss Weight Optimization with Multiple Frequency Constraints Formulation of the Structural Optimization with Frequency Constraints Introduction of Selected Chaos Map Numerical Examples of Optimal Truss Design.			

MODULE- IV	8 Hours
Chaotic Teaching Learning Based Optimization Introduction Standard Teaching–Learning-Based Optimization (TLBO) Basic Steps in Standard Teaching–Learning-Based Optimization Chaos Enhanced Teaching–Learning-Based Optimization (CTLBO) Truss Weight Optimization with Static Constraints Formation of the Objective Function and Constraint Conditions Introduction of Selected Chaos Map Numerical Examples of Optimal Truss Design Truss Weight Optimization with Multiple Frequency Constraints Truss Size and Layout Optimization with Multi Frequency Constraints Introduction of Selected Chaos Map Numerical Examples of Optimal Truss Design.	
MODULE- V	7 Hours
Chaotic Biogeography Based Optimization Introduction Standard Biogeography-Based Optimization (BBO) Basic Steps of Biogeography-Based Optimization Chaos Enhanced Biogeography-Based Optimization (CBBO) Truss Weight Optimization with Static Constraints Formulation of the Structural Optimization Problems Introduction of Selected Chaos Map Numerical Examples of Optimal Truss Design Truss Weight Optimization with Multiple Frequency Constraints Formulation of the Structural Optimization with Multi-frequency Constraints Numerical Examples of Optimal Truss Design.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Demonstrate proficiency in the application of various heuristic algorithms for solving global optimization problems.	L1
2	Critically evaluate the strengths and weaknesses of different heuristic approaches in the context of specific optimization challenges.	L1
3	Implement selected heuristic algorithms using programming languages, showcasing their ability to solve real-world optimization scenarios.	L2
4	Analyze results from heuristic optimization processes, interpreting data and drawing meaningful conclusions to inform decision-making.	L6
5	Communicate effectively the methodologies and outcomes of their optimization projects through presentations and written reports, demonstrating clarity and professionalism.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Thanigaivelan Rajasekaran, Suchithra M, Kalliappan S, Mothilal S, 'Metaheuristics Algorithm and Optimization of Engineering and Complex Systems', IGI Global.
2. Linas Mockus, Jonas Mockus, Audris Mockus, reklaitis, William Eddy, 'Bayesian Heuristic Approach to Discrete and Global Optimization: Algorithms, Visualization, Software, and Applications, Springer; 1997th edition.
3. Zbigniew Michalewicz, David B. Fogel – *How to Solve It: Modern Heuristics*, Springer, 2nd Edition, 2004.
4. Xin-She Yang – *Nature-Inspired Metaheuristic Algorithms*, Luniver Press, 2nd Edition, 2010.

REFERENCE BOOKS:

1. Fred Glover, Gary A. Kochenberger – *Handbook of Metaheuristics*, Springer, 2nd Edition, 2010.
2. Yaroslav D. Sergeyev, Dmitri E. Kvasov – *Deterministic Global Optimization: An Introduction to the Diagonal Approach*, Springer, 2017.

COGNITIVE ARCHITECTURES

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

SEMESTER – VI

Course Code : 23RA3609	Credits : 03
Hours / Week : 03	Total Hours : 39
L-T-P-J : 3-0-0-0	CIE+SEE : 60+40 Marks

Course Objectives:

This course will enable students to:

1. **Define** the concept of cognitive architecture and its significance in understanding both human cognition and artificial intelligence systems.
2. **Describe** the key components and structures of various cognitive architectures, including their fixed structures and interactions that facilitate intelligent behavior.
3. **Compare and contrast** different cognitive architectures, evaluating their effectiveness in simulating cognitive processes and their applications in fields such as robotics and virtual agents.
4. **Design** a basic cognitive architecture model that embodies principles of cognitive science, demonstrating an understanding of how knowledge drives intelligent behavior.
5. **Assess** the implications of cognitive architectures on the development of intelligent systems, including ethical considerations and the potential impact on society.

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** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I

08 Hours

Introduction to Cognitive Science and Cognitive Computing with AI

Cognitive Computing, Cognitive Psychology, The Architecture of the Mind, The Nature of Cognitive Psychology, Cognitive architecture, Cognitive processes, The Cognitive Modeling Paradigms, Declarative / Logic based Computational cognitive modeling, connectionist models – Bayesian models. Introduction to Knowledge-Based AI – Human Cognition on AI – Cognitive Architecture.

UNIT – II

08 Hours

Cognitive Computing with Inference and Decision Support Systems

Intelligent Decision making, Fuzzy Cognitive Maps, learning algorithms: Nonlinear Hebbian Learning, Data driven NHL, Hybrid learning, Fuzzy Grey cognitive maps, Dynamic Random fuzzy cognitive Map.

UNIT – III

08 Hours

Cognitive Computing with Machine Learning

Machine learning Techniques for cognitive decision making, Hypothesis Generation and Scoring, Natural Language Processing, Representing Knowledge, Taxonomies and Ontologies, N-Gram models, Application.

UNIT – IV	8 Hours
Cognitive Architecture and Artificial Intelligence The role of cognitive architecture in AI development. Integration of cognitive architectures with machine learning techniques. Ethical considerations in the design of intelligent agents. Principles of designing effective cognitive architectures. Tools and methodologies for modeling cognitive systems. Hands-on project: Designing a simple cognitive architecture.	
UNIT – V	7 Hours
Case Studies Cognitive Systems in health care, Cognitive Assistant for visually impaired – AI for cancer detection, Predictive Analytics, Text Analytics, Image Analytics, Speech Analytics – IBM Watson – Introduction to IBM’s Power AI Platform - Introduction to Google’s TensorFlow Development Environment	

Course Outcomes

Course Outcomes (COs)	Description	Bloom’s TaxonomyLevel
At the end of the course the student will be able to:		
1	Articulate a comprehensive understanding of cognitive architecture concepts, including their relevance to both cognitive science and artificial intelligence.	L1
2	Analyze and evaluate various cognitive architectures, demonstrating the ability to identify their strengths and weaknesses in simulating human cognitive processes.	L1
3	Design and implement a basic cognitive architecture model, applying theoretical principles to create a functional system that mimics specific cognitive behaviors.	L2
4	Critically assess the ethical implications and societal impacts of cognitive architectures in the development of intelligent systems, fostering a responsible approach to AI.	L6
5	Demonstrate effective collaboration and communication skills through group projects, showcasing the ability to work as part of a team to solve complex problems related to cognitive architecture.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Maria Isabel Aldinhas Ferreira, João Silva Sequeira, Rodrigo Ventura, 'Cognitive Architectures', Springer – Volume 94.
2. R. L. Lewis, 'Cognitive Architectures and Human-like Intelligence: An Overview of Current Approaches,' Published by Wiley-IEEE Press, Hoboken, New Jersey, United States, 2019.

REFERENCE BOOKS:

1. The Soar Cognitive Architecture, John E. Laird. Penguin Books.
2. Cognitive Architecture: Designing for How We Respond to the Built Environment, Ann Sussman & Justin Hollander.

AGRICULTURAL ROBOTICS

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

SEMESTER – VI

Course Code	: 23RA3610	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This course will enable students to:

1. **Explain** the basic principles of robotics, including sensors, actuators, and control systems, with a focus on their applications in agriculture.
2. **Understand** the role of robotics in enhancing sustainability and productivity in agriculture.
3. **Develop** the ability to design, program, and prototype simple robotic systems tailored to agricultural tasks.
4. **Learn** about 3D Sensing Techniques and Systems.

Teaching-Learning Process (General Instructions)

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

1. **Lecture method** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I

08 Hours

Introduction

Fundamental Technologies for Agricultural and Field Robotics: Sensing and Situation Awareness, Challenges and Opportunities. Economics. Sensors I: Color Imaging and Basics of Image Processing, Basics of Color Imaging: Color Representation, Color Space Conversion, Color Comparison. Image Acquisition, Basic Image Processing Operations: Image Enhancement – Histogram, Morphological Operations, Segmentation - Pixel-Wise Techniques, Region-Based Segmentation, Features of Objects of Interest. Hough Transform, Pattern Matching, Things to Consider.

UNIT – II

08 Hours

Sensors II: 3D Sensing Techniques and Systems

3D Measurement Principles: 3D from 2D Images, 3D with Time-of-Flight of Light, Structured Light, Stereo-Vision System: Depth Estimation Using Stereo-Vision Camera, Camera Calibration, Image Correspondence, Epipolar Geometry, Tools for Stereo-Vision-Based Distance Measurement. Other 3D Measurement Systems: Visual Servoing, Laser and LIDAR, 3D Camera, Global Navigation Satellite Systems (GNSS), Interferometric Synthetic Aperture RADAR (InSAR), Ultrasonic and Infrared Techniques.

UNIT – III

08 Hours

Robotic Manipulation and Optimization for Agricultural and Field Applications

Design Considerations/Constraints: Workspace Considerations, Target Performance Metrics, Required Manipulability, Speed vs Robustness, Robotic Manipulation, Kinematics and Dynamics, Path and Trajectory Planning: Collision-Free Path Planning. Optimization.

UNIT – IV	8 Hours
Modeling, Simulation, and Visualization of Agricultural and Field Robotic Systems Simulation Requirements, Modeling Background, Dynamical System Modeling, Simulation and Visualization Platforms, Robot Models, Virtual World Models, Collision Detection, Sensor Models, Comparison Between Robotic Simulation Techniques, Modeling Agricultural Field Elements - Modeling and Simulating Soil-Machine Interactions, FEM Soil Modeling, DEM Soil Modeling, Simulation-Based Comparison of Soil Modeling with DEM and FEM, Modeling and Simulating Perception Systems, Modeling and Simulating Machine Operators.	
UNIT – V	7 Hours
Advanced Learning and Classification Techniques for Agricultural and Field Robotics: Learning Algorithms, Common Learning Models, Learning Weights with Gradient Descent, Deep Learning, An Overview of Applications of Machine Learning in Agriculture – Classification, Clustering.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand the Fundamentals of Agricultural Robotics.	L1
2	Implement Sensor Technologies for Agricultural Robotics	L1
3	Discuss the principles of robotic systems, sensors, and actuators used in agricultural applications.	L2
4	Design robots for specific agricultural tasks.	L6
5	Understand the Fundamentals of Machine Learning and Classification Techniques	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Manoj Karkee Qin Zhang, 'Fundamentals of Agricultural and Field Robotics', Springer.
2. A. R. R. Sharma, M. C. P. P. Singh, and S. N. Kumar, "Agricultural Robotics: Design, Control, and Applications", Published by Springer, Cham, Switzerland, 2021.
3. M. A. Hsieh, S. T. Lee, and W. J. D. Ng, "Robotic Systems for Agriculture: Autonomous Technologies for Precision Farming", Published by Wiley-IEEE Press, Hoboken, New Jersey, United States, 2020.

REFERENCE BOOKS:

1. C. K. A. Sharma, A. J. Gupta, and A. K. Verma, "Advances in Agricultural Robotics: Automation in Modern Farming", Published by CRC Press, Boca Raton, Florida, United States, 2019.
2. S. S. B. T. Z. Lee, and A. M. S. K. Chang, "Robots for Precision Agriculture: Theory and Applications", Published by Elsevier, Amsterdam, Netherlands, 2021.

PROFESSIONAL ELECTIVE COURSE -III

MULTI-ROBOT SYSTEMS			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Course Code	: 23RA3611	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Understand the Fundamentals of Multi-Robot Systems. 2. Understand the Basics of Wheeled Mobile Robots. 3. Study Kinematic Models for Wheeled Mobile Robots. 4. Understand the Fundamentals of Micro-Robotics. 5. Explain the concepts of localization and mapping and their importance in autonomous mobile robotics.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			08 Hours
Introduction to Mobile Robots Tasks of mobile robots, Robot's manufacturers, Type of obstacles and challenges, Tele-robotics, philosophy of robotics, Service robotics, Types of environment representation. Ground Robots: Wheeled and Legged Robots, Aerial Robots, Underwater Robots and Surface Robots.			
UNIT – II			08 Hours
Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four - wheeled robots, omnidirectional and mecanum wheeled robots). Sensors for localization: magnetic and optic position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, GNSS and Sensors for navigation: tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual system.			
UNIT – III			08 Hours
Localization and Mapping in mobile robotics Motion Control of Mobile Robots (Model and Motion based Controllers): Lyapunov-based Motion Control Designs and Case Studies. Understand the current application and limitations of Mobile Robots. Introduction to Mobile Manipulators and Cooperative Mobile Robots			
UNIT – IV			8 Hours
Micro-robotics Introduction, Task specific definition of micro-robots - Size and Fabrication Technology based definition of micro-robots - Mobility and Functional-based definition of micro-robots - Applications for MEMS based micro-robots. Implementation of Micro-robots: Arrayed actuator principles for micro-robotic applications – Micro-robotic actuators.			

UNIT - V		7 Hours
Design of Locomotive Micro-Robot Devices Based on Arrayed Actuators Micro-robotics devices: Micro- grippers and other micro-tools - Micro-conveyors - Walking MEMS Micro-robots – Multirobot system: Micro-robot powering, Micro-robot communication. Microfabrication and Micro-assembly: Micro-fabrication principles - Design selection criteria for micromachining - Packaging and Integration aspects – Micro-assembly platforms and manipulators.		

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Discuss the design considerations of wheeled mobile robots, including types of wheels and mobility configurations.	L1
2	Develop and analyze kinematic models of wheeled robots for various configurations.	L1
3	Implement control techniques for controlling the movement of wheeled robots, such as trajectory planning and path following.	L2
4	Understand the Use of Micro-Robots in Environmental Monitoring and Exploration	L6
5	Understand the fundamental challenges in coordinating multiple robots to achieve a common goal, including communication, synchronization, and conflict resolution.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3
3: Substantial (High)				2: Moderate (Medium)								1: Poor (Low)			

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Sacramuzza, Introduction to Autonomous Mobile Robots, MIT press, 2nd edition, 2011..
2. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, –Principles of Robot Motion-Theory, Algorithms, and Implementation, MIT Press, Cambridge, 2005.

REFERENCE BOOKS:

1. Atnaik, Srikanta, "Robot Cognition and Navigation: An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.
2. Spyros G. Tzafestas, "Introduction to Mobile Robot Control", Elsevier, 2021.
3. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg, 2008

BLOCKCHAIN AND SECURITY IN AI [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VI			
Course Code	: 23RA3612	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Learn the underlying principles and techniques associated with block chain Technologies. 2. Understand and describe how blockchain works 3. Familiarize with Ethereum, smart contracts and related technologies, and solidity language. 4. Understand the application of Blockchain in various domains.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			08 Hours
Introduction to Blockchain Distributed systems, P2P network Architecture of Blockchain, Generic elements of a blockchain: How blockchain works, Benefits, features, and limitations of blockchain How blockchain accumulates blocks, types of blockchain, Distributed ledger, Consensus mechanisms -Proof of work, Proof of Stake, Proof of Authority, CAP theorem, Decentralization, Disintermediation, Ecosystem - Storage, Communication and Computation.			
UNIT – II			08 Hours
Cryptography and Smart Contracts Symmetric cryptography (DES, AES), Asymmetric cryptography, Public and Private keys, Algorithms - RSA, Hash functions, SHA, SHA-256 Smart contracts - Benefits of Smart contracts, Solidity Programming-Types, Literals, Enums, write basic program using Solidity, Compile, verify and deploy.			
UNIT – III			08 Hours
Ethereum Blockchain The Ethereum network, Ethereum Virtual Machine Execution Environment, Opcodes and their meaning, Structure of a Block, Genesis Block, Merkle tree, Geth, Transactions, Transaction receipts, Nonce, Gas – gas Price, gas Limit, Ether, Mining, Wallets, Ethereum network (main net, test net), Metamask.			
UNIT – IV			8 Hours
Ethereum Development Infura, Web3.0 for Blockchain, Web3J -Java frontend, Creating Blockchain network and peering, Truffle - build contract, migrate and deploy, Ganache CLI			
UNIT – V			7 Hours

Hyperledger

Projects under Hyperledger, Hyperledger reference architecture, Hyperledger design principles, Hyperledger Fabric, Hyperledger Sawtooth, Case study: Blockchain in IoT

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Recall basic blockchain and cryptography concepts.	L2
2	Comprehend mining and Merkle tree concepts in blockchain.	L2
3	Utilize Solidity for real-world smart contract development.	L3
4	Evaluate Ethereum tools like Geth and Truffle for blockchain applications.	L5
5	Apply blockchain in IoT and healthcare via Hyperledger.	L3

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

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

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Lantz, Lorne, and Daniel Cawrey. Mastering blockchain. O'Reilly Media, 2020.
2. Comuzzi, Marco, Paul Grefen, and Giovanni Meroni. Blockchain for Business: IT Principles into Practice. Routledge, 2023.

REFERENCE BOOKS:

1. Bashir, Imran. Mastering blockchain. Packt Publishing Ltd, 2017.
2. Raj, Pethuru, Kavita Saini, and Chellammal Surianarayanan, eds. Blockchain technology and applications. CRC Press, 2020.
3. Dave, Chintan. Security Challenges with Blockchain: Navigate Blockchain Security Challenges, Unveil Vulnerabilities, and Gain Practical Strategies for Secure Application Development (English Edition). Orange Education Pvt Ltd, 2024.
4. Julie, E. Golden, J. Jesu Vedha Nayahi, and Noor Zaman Jhanjhi, eds. Blockchain Technology: Fundamentals, Applications, and Case Studies. CRC Press, 2020.

Activity Based Learning (Suggested Activities in Class):

1. Group Discussion.

EXPERT SYSTEMS AND APPLICATIONS

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

SEMESTER – IV

Course Code	: 23AIR3613	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This course will enable students to:

1. **Understand** the Fundamentals of Expert Systems
2. **Develop** the ability to identify and analyze problems suitable for expert system solutions.
3. **Identify** real-world applications of expert systems in fields such as healthcare, finance, engineering, and education.
4. **Understand** the role of expert systems in the context of intelligent systems and modern AI-driven applications.
5. **Learn** the methodologies for building expert systems, including knowledge acquisition techniques and validation processes.

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** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I

08 Hours

Introduction to Artificial Intelligence

The Turing Test, Intelligent Agents- Software Agents, Physical Agents. Approaches in Artificial Intelligence, AI Problems, Features of AI Programs, Importance of AI.

UNIT – II

08 Hours

Applications of Artificial Intelligence: Finance, Hospitals and Medicine, Robotics, Expert Systems, Diagnosis, Pattern Recognition, Natural Language Processing, Game Playing, Image Processing, Data Mining, Big Data Mining.

UNIT – III

07 Hours

Expert Systems: Definitions of Expert Systems, Features of Good Expert Systems, Architecture and Components of Expert Systems, User Interface, Knowledge Base, Working Storage (Database), Inference Engine, Explanation Facility, Knowledge Acquisition Facility, External Interface. Roles of the Individuals Who Interact with the System - Domain Expert, Knowledge Engineer, Programmer, Project Manager, User. Advantages of Expert Systems, Disadvantages of Expert Systems.

UNIT – IV

08 Hours

The Expert System Development Life Cycle: Stages in the Expert System Development Life Cycle - Problem Selection, Conceptualization, Formalization, Prototype Construction, Implementation, Evaluation. Sources of Error in Expert System Development - Knowledge Error, Syntax Errors, Semantic Errors, Inference Engine Errors, Inference Chain Errors.

UNIT – V	08 Hours
Fuzzy Expert Systems: The Need for Fuzzy Expert Systems, Operations on a Fuzzy Expert System Fuzzification (Fuzzy Input), Fuzzy Operator, Fuzzy Inferencing (Implication), Aggregate All Output, Defuzzification, Fuzzy Inference Systems, Mamdani Fuzzy Inference Method, Sugeno Inference Method (TSK Fuzzy Model of Takagi, Sugeno, and Kang), Choosing the Inference Method, The Fuzzy Inference Process in a Fuzzy Expert System, Monotonic Inference Non-Monotonic Inference, Downward Monotonic Inference, Types of Fuzzy Expert Systems, Fuzzy Control, Fuzzy Reasoning, Fuzzy Controller, Components of a Fuzzy Controller, Application Areas of Fuzzy Controller.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the structure, components, and working of expert systems and differentiate them from other types of AI systems.	L2
2	Apply Knowledge Representation Techniques	L2
3	Demonstrate Inference and Reasoning Skills	L2 & L3
4	Implement forward and backward chaining inference mechanisms to solve problems.	L2
5	Address uncertainty in decision-making using techniques like fuzzy logic and probabilistic reasoning.	L2 & L3

Mapping Levels of COs to POs / PSOs

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
CO-1	1	1	1	1	1	-	-	-	-	-	-	1	1	1	1
CO-2	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO-3	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO-4	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2
CO-5	2	2	2	2	2	-	-	-	-	-	-	1	2	2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

- Gupta, U. G. Artificial Intelligence and Expert Systems. Mercury Learning and Information, 2020.
- Turban, Efraim, Jay E. Aronson, Ting-Peng Liang, and Ramesh Sharda. Decision Support and Business Intelligence Systems. Pearson, 2010.
- Giarratano, Joseph, and Gary Riley. Expert Systems: Principles and Programming. Cengage Learning, 2004.

REFERENCE BOOKS:

- Sasikumar, M., S. Ramani, and S. M. Vijayalakshmi. Rule-Based Expert Systems: A Practical Introduction. Narosa Publishing, 2007.

ROBOTIC LOGISTICS AND WAREHOUSING

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

SEMESTER – VI

Course Code : 23RA3614	Credits : 03
Hours / Week : 03	Total Hours : 39
L-T-P-J : 3-0-0-0	CIE+SEE : 60+40 Marks

Course Objectives:

This course will enable students to:

1. **Understand** the Fundamentals of Logistics and Robotics: Explain the key concepts of logistics, supply chain management, and the role of robotics in enhancing operational efficiency.
2. **Analyze** Different Types of Robots: Identify and differentiate between various types of robots used in warehousing, including mobile robots, collaborative robots, and specialized robotic systems.
3. **Evaluate** Automation Technologies: Assess the functionalities of Warehouse Management Systems (WMS) and their integration with robotics, as well as the impact of machine learning and IoT on warehouse operations.
4. **Design** Automated Warehouse Solutions: Develop practical skills in designing automated warehouse systems, including layout optimization and workflow efficiency, through collaborative projects.
5. **Address Future Challenges and Ethical Considerations**: Critically analyze the challenges of implementing robotics in logistics, including workforce implications, ethical considerations, and sustainability practices.

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** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching**: incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I	08 Hours
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Overview of Logistics and Warehousing

Introduction to logistics and supply chain management Importance of warehousing in the supply chain Fundamentals of Robotics Basic concepts of robotics Types of robots used in logistic Automation in Warehousing Overview of automation technologies Benefits of robotics in warehousing operations.

UNIT – II	08 Hours
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Types of Robots in Warehousing

Mobile Robots and Autonomous Guided Vehicles (AGVs) Characteristics and applications of mobile robots Case studies of AGVs in real-world scenarios Collaborative Robots (Cobots) Understanding cobots and their role in warehousing Safety considerations and human-robot collaboration Specialized Robots Overview of robotic arms and automated storage and retrieval systems (AS/RS) Applications and case studies.

UNIT – III	08 Hours
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Automation Technologies in Logistics Warehouse Management Systems (WMS) Introduction to WMS and its functionalities Integration of robotics with WMS Machine Learning and Data Analytics Role of data analytics in optimizing warehouse operations Machine learning applications in logistics Internet of Things (IoT) in Warehousing.

Understanding IoT and its impact on logistics Case studies of IoT-enabled warehouses.

UNIT – IV	8 Hours
Designing Automated Warehouse Systems Key Components of Automated Warehouses Layout design and workflow optimization Selecting the right robotic solutions Practical Design Project Students will work in groups to design an automated warehouse system Presentations of design concepts and feedback sessions Simulation and Testing Introduction to simulation tools for warehouse design Testing and evaluating design effectiveness.	
UNIT – V	7 Hours
Future Trends and Challenges in Robotic Logistics Emerging Technologies in Robotics Overview of advancements in robotic technologies Future trends in robotic logistics Challenges of Implementing Robotics Identifying barriers to adoption in the industry Workforce implications and training needs Ethical Considerations and Sustainability Discussing the ethical implications of robotics in logistics Exploring sustainable practices in automated warehousing.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the fundamental principles of logistics, supply chain management, and the significance of robotics in these fields.	L1
2	Differentiate Robot Types: Identify and describe the various types of robots utilized in warehousing, including their specific applications and advantages.	L1
3	Assess Automation Technologies: Evaluate the functionalities of Warehouse Management Systems (WMS) and analyze how robotics and data analytics enhance warehouse operations.	L2
4	Design Automated Solutions: Collaboratively design an automated warehouse system, demonstrating the ability to optimize layout and workflow for efficiency.	L6
5	Analyze Future Trends: Critically assess emerging trends and challenges in robotic logistics, including ethical considerations and sustainability practices.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Zhang, John, and Xiao Liu, eds. Intelligent Robotics for Logistics and Warehousing. Springer, 2020.
2. Mobile Robot Automation in Warehouses: A Framework for Decision Making and Integration Authored by Alp Yildirim, Hendrik Reefke, and Emel Aktas, 2023.
3. Robotics for Intralogistics in Supermarkets and Retail Stores, Luigi Villani, Michael Beetz, Bruno Siciliano, Springer, 2022

REFERENCE BOOKS:

2. Xu, Yun, and Xiaoyu He, eds. Advanced Robotics for Warehouse Management. CRC Press, 2021.
3. Bogue, Robert. Robotics and Automation in the Warehouse: A Guide to the New Industrial Revolution. Emerald Group Publishing, 2018.

VII-Semester Syllabus

FUNDAMENTAL OF ECONOMICS

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

SEMESTER – VII

Subject Code	: 23RA4701	Credits	: 04
Hours / Week	: 04	Total Hours	: 39
L-T-P-J	: 3-1-0-0	CIE+SEE	: 60+40 Marks

Course objectives:

The objectives of this course are to:

1. **Explain** fundamentals management functions of a manager. Also explain planning and decision-making processes.
2. **Explain** the organizational structure, staffing and leadership process.
3. **Describe** the understanding of motivation and different control systems in management.
4. **Explain** understanding of Entrepreneurships and Entrepreneurship development process.
5. **Illustrate** Small Scale Industries, various types of supporting agencies and financing available for an entrepreneur.
6. **Summarize** the preparation of project report, need significance of report. Also to explain about industrial ownership.

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

The Price System

Allocation mechanisms - Signals, speculation and prediction - Price ceilings and price floors, Price gouging - General Equilibrium Theory, Two Fundamental Theorems of Welfare Economics, Theory of Second Best - Hierarchy of plans.

UNIT – II

08 Hours

Market Mechanism

Competition and entry, creating barriers to entry, the benefits of competition (consumer's surplus, creating destruction) Alternatives to the market (disagreement, cartels, collusion, monopolization eBay and Online markets Asymmetric information, Market failure Market problems and Government (externalities, common ownership, public goods)

UNIT – III

10 Hours

National and Global Issues

GDP and the measurement of progress, nominal and real measures, flow of income and expenditure Business cycles, historical records and indicators, inflationary records, Transmission and amplification measures, Monetary policy and fiscal policy The Economy in the Long Run- economic growth, productivity and living standards, savings and capital formation, catching up vs cutting edge, money, prices and federal finance, financial markets and international capital flows The foreign exchange market, balance of payment, current and capital account, exchange rate and open economy International Trade Theory – Classical, Heckscher

Ohlin, New Trade Theory	
UNIT – IV	7 Hours
Social Issues Discrimination, the market, statistical discrimination, minimum wage, gender discrimination, exclusion Income inequality and poverty, causes of income inequality and poverty (inflation) income distribution over time, the official poverty rate Unemployment, measurement, types and cost of unemployment, interpreting the unemployment rate, social security Governance and Corruption - - Global warming – the market for natural resources, environmental problems, mitigation of global warming.	
UNIT – V	6 Hours
Game Theory Strategic form games and Nash equilibrium Rationalizability and inter related elimination of dominated actions Bayesian games and correlated equilibrium Extensive form games with perfect information Bargaining Repeated games Extensive form games and imperfect and incomplete information	

Course Outcomes

Course Outcome (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understanding of the Price System and Market Mechanisms	L2 & L3
2	Gain an understanding of key economic indicators such as GDP, inflation, and business cycles, and how they relate to fiscal and monetary policies.	L2 & L3
3	Critical Awareness of various social issues related to economics, such as income inequality, poverty, unemployment, gender discrimination, and the effects of inflation.	L2 & L3
4	Identify market failures, such as externalities, public goods, and monopolization, and analyze the role of government intervention in addressing these issues.	L2 & L3
5	Acquire knowledge of game theory and its application in strategic decision-making.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	3	3	-	-	3	-	-	-	-	-	3	3	3
CO-2	3	3	-	3	-	3	-	-	3	-	-	-	3	3	3
CO-3	-	3	3	-	-	3	3	3	-	-	-	-	3	3	3
CO-4	-	3	3	-	3	3	-	-	-	3	-	-	3	3	3
CO-5	-	3	3	-	-	-	3	3	-	-	-	3	3	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

Text Books:

1. Mas-Collel, Whinston & Green, Microeconomic Theory, OUP and D Fudenberg & J Tirole, Game Theory, MIT Press.
2. Kreps, D M, A Course in Microeconomic Theory, Harvester Wheatsheaf; H R Varian, Microeconomic Analysis (3rd edn), Norton
3. Osbourne, M J & A Rubinstein, A Course in Game Theory, MIT Press
4. Jehle, G A & P J Reny, Advanced Microeconomic Theory, Longman.
5. Romer, D., Advanced Macroeconomics, McGraw-Hill Advanced Series in Economics, New York, 1996.

Reference Books:

1. Acemoglu, D., Introduction to Modern Economic Growth, Princeton University Press, 2009
2. Barro, R J & X Sala-i-Martin, Economic Growth, McGraw-Hill, 1997.
3. Ljungqvist, L & T Sargent, Recursive Macroeconomic Theory, MIT Press, 2000
4. Stokey, N & R E Lucas, Recursive Methods in Economic Dynamics, Harvard University Press, 1989.
5. Obstfeld, M & K Rogoff, Foundations of International Macroeconomics, MIT Press, 2000
6. Aghion, P & P Howitt, Endogenous Growth Theory, MIT Press 1998 12. Pissarides, C A, Equilibrium Unemployment Theory, MIT Press 2000.

COGNITIVE SYSTEMS IN AI AND ROBOTICS

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

SEMESTER – VII

Course Code : 23RA4702	Credits : 04
Hours / Week : 04	Total Hours : 39
L-T-P-J : 3-0-0-2	CIE+SEE : 60+40 Marks

Course Objectives:

This course will enable students to:

1. **Understand** Cognitive Systems: Explain the fundamental concepts and theories behind cognitive systems in artificial intelligence and robotics.
2. **Analyze** Learning Mechanisms: Evaluate various learning mechanisms used in cognitive robotics, including supervised, unsupervised, and reinforcement learning.
3. **Implement** Knowledge Representation: Demonstrate the ability to represent knowledge effectively using different models and frameworks applicable to cognitive systems.
4. **Integrate** Perception and Action: Assess how perception systems and sensor integration contribute to the functionality of cognitive robots in real-world applications.
5. **Engage** in Human-Robot Interaction: Analyze the principles of human-robot interaction and apply ethical considerations in the design and implementation of cognitive robotic systems.
6. **Explore** Future Trends: Investigate emerging trends and challenges in cognitive systems, preparing students for advancements in AI and robotics technologies.

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** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I

08 Hours

Introduction to Cognitive Systems

Definition and Scope of Cognitive Systems, Historical Development of AI and Cognitive Science, Key Concepts in Cognitive Systems, Cognitive Architectures, Applications of Cognitive Systems in Robotics.

UNIT – II

08 Hours

Cognitive Robotics and Learning Mechanisms

Introduction to Cognitive Robotics, Cognitive Architectures in Robotics, Learning Mechanisms in Cognitive Systems, Prediction Systems and Error Reduction, Applications of Cognitive Robotics in Real-World Scenarios.

UNIT – III

08 Hours

Machine Learning and Cognitive Processes

Introduction to Machine Learning, Supervised vs. Unsupervised Learning, Reinforcement Learning, Cognitive Models in Machine Learning, Applications of Machine Learning in Robotics

UNIT – IV

8 Hours

Perception and Sensor Integration

Understanding Perception in Cognitive Systems, Sensor Technologies and Data Fusion, Computer Vision Fundamentals, Natural Language Processing in Robotics, Case Studies of Perception in Robotic Systems.

UNIT – V		7 Hours
Human-Robot Interaction and Ethics Principles of Human-Robot Interaction (HRI), Cognitive Models of Interaction, Ethical Considerations in AI and Robotics, Social Implications of Cognitive Robotics, Future Trends in Cognitive Systems.		

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain Key Concepts: Articulate the fundamental principles of cognitive systems, artificial intelligence, and their applications in robotics.	L1
2	Analyze Cognitive Robotics: Evaluate the role of cognitive architectures in robotics and how they facilitate learning and adaptation in robotic systems.	L1
3	Implement Learning Mechanisms: Demonstrate the ability to apply various learning mechanisms, including supervised, unsupervised, and reinforcement learning, in cognitive robotic applications.	L2
4	Integrate Perception Systems: Integrate sensor technologies and perception systems to enhance the functionality and autonomy of robotic systems.	L6
5	Assess Human-Robot Interaction: Critically assess the principles of human-robot interaction and the ethical implications of deploying cognitive systems in real-world scenarios.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Russell, S., & Norvig, P., "Artificial Intelligence: A Modern Approach," 4th ed., Pearson, 2020.
2. Poole, D., & Mackworth, A., "Artificial Intelligence: Foundations of Computational Agents," Cambridge University Press, 2017.
3. Thrun, S., Burgard, W., & Fox, D., "Probabilistic Robotics," MIT Press, 2005.

Reference Books:

1. Brooks, R., "Cambrian Intelligence: The Early History of the New AI," MIT Press, 1999.
2. Khatib, O., "Human-Centered Robotics," Springer, 2018.

CAPSTONE PROJECT-PHASE I

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

SEMESTER – VII

Subject Code : 23RA4703

Credits : 03

Hours / Week : 06

Total Hours : 78

L-T-P-J : 0-0-0-6

CIE+SEE : 100 Marks

Course Objectives:

This Course will enable students to:

1. **Apply** theoretical knowledge to solve practical problems.
2. **Enhance** technical, analytical, and problem-solving skills.
3. **Foster** teamwork and collaboration skills.
4. **Develop** creativity and innovation in addressing engineering challenges.
5. **Analyze** and design the solution to the selected problem statement.

DESCRIPTION:

1. Each B. Tech Project must be carried out by a group of students at the Institute. To ensure uniform participation of each student, the group size should be preferably at least 3 but not more than 4 students.
2. Each project activity must be supervised by the faculty members of the Institute. These faculty members are termed Project Guides.
3. In case the project is of multi-disciplinary nature, the Project group can be formed consisting of students from other departments. But there must be at least one student and a project Guide from the department who is offering the Project.
4. The topic proposed by both the guide and the student team should be approved by the department chairman and the department project coordinator to proceed further. A degree of industrial input and involvement will be encouraged and can be facilitated through existing academic-industrial collaborations or by addressing specific topics that are of interest to industrial partners.
5. All projects will be closely supervised by the Project Guide with ongoing feedback and guidance at all stages of the project from conception to completion.
6. The following criteria will be checked by the department chairman to approve for the project proposal:
 - a. Department staff as Project guide
 - i. Ability to provide direction to the student in the chosen field of interest to formulate a suitable title of the project.
 - ii. Ability to design an appropriate strategy and methodology to carry out the Project by the team.
 - iii. Ability to provide and evaluate the strong literature review document for the chosen topic
 - iv. Ability to train students on paper / technical writing skills
 - b. Student Team
 - i. To be dedicated and committed to work on the project by sharpening the existing and learning new technical skills.
 - ii. To be committed to completing the project and participate in hackathons and project exhibitions.
8. Phase-1 comprises of Literature Survey, Problem identification, Objectives and Methodology.
9. There will be CIA evaluation (Project reviews) done by a committee of senior faculty of the department based on the rubrics

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Demonstrate the ability to apply engineering principles to solve real-world problems.	L1
2	Develop innovative thinking and thereby preparing students for Capstone project	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	-
CO-2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

OPEN ELECTIVES – II

LEAN START-UP METHODOLOGY [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Subject Code	: 23RA4704	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This Course will enable students to: 1. Analyze the opportunities and identify the potential problem to build a solution 2. Devise the solution to solve the given problem and build core PoC and business model. 3. Explain the business model iterations based on the Field experience with customers. 4. Get the idea of acquiring / retaining customers as well basic finance aspects. 5. Describe and illustrate the current and future path forward of your (potential) start-up.			
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> adopted to develop the course outcomes. 2. Interactive Teaching: 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, by following Idea to PoC to deliver to customer(s) leveraging business model(s) and iterate based on their feedback. 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. Encourage students to apply the learnings to the real world with on field experience in helping to improve their understanding.			
UNIT – I			06 Hours
VISION Start, Define, Learn & Experiment. (Text Book-1: Chapter 1 - 4)			
UNIT – II			06 Hours
STEER Leap, Test, Measure & Pivot (Text Book-1: Chapter 5 - 8)			
UNIT – III			07 Hours
ACCELERATE Batch, Grow, Adapt, Innovate (Text Book-1: Chapter 9 – 12)			
UNIT – IV			10 Hours
BUSINESS MODEL PART I			

Business Model Definition, 9 Building Blocks, Business Model Canvas, Patterns (Text Book-2: Page 14 - 125).

UNIT – V	10 Hours
BUSINESS MODEL PART II Design – Customer insights, Ideation, Prototyping, Story Telling. Strategy – BM environment, Evaluating BM's, Manage. Process – Business Model Design Process. (Text Book-2: Page # 126 - 261)	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain their understanding of Business model leveraging their field experience.	L1
2	Interpret and evaluate the Business Model(s).	L2
3	Describe the Lean Start up Methodology with their practical experience.	L2
4	Identify and explain the success and failures using Business Model(s).	L1
5	Register Start-Up (Optional).	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	-	-	-	-	-	-	-	-	-	2	-	3	-
CO-2	3	3	2	-	-	-	-	-	-	-	-	2	-	3	-
CO-3	3	3	-	-	-	-	-	-	-	-	-	1	-	3	-
CO-4	3	3	2	-	-	-	-	-	-	-	-	2	-	3	-
CO-5	2	2	-	-	-	-	-	-	-	-	-	1	-	3	-

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

- Eric Ries "The Lean Startup", ISBN-978-0670921607.
<https://ia801206.us.archive.org/31/items/TheLeanStartupErickRies/The%20Lean%20Startup%20-%20Erick%20Ries.pdf>
- Alex Osterwalder, Yves Pigneur "Business Model Generation Handbook" ISBN-978-0-470-87641-1
[http://alvarestech.com/temp/PDP2011/pdf/Business%20Model%20Generation%20\(1\).pdf](http://alvarestech.com/temp/PDP2011/pdf/Business%20Model%20Generation%20(1).pdf)

REFERENCE BOOKS:

- Steve Blank "The Four Steps to the Epiphany: Successful Strategies for Products That Win", ISBN-13 : 978-0989200509
- The Entrepreneur's Guide to Customer Development: A "Cheat Sheet" to the Four Steps to the Epiphany Paperback – Import, 6 February 2012, ISBN-13 : 978-0982743607

E-Resources:

1. <https://ia801206.us.archive.org/31/items/TheLeanStartupErickRies/The%20Lean%20Startup%20-%20Erick%20Ries.pdf>
2. [http://alvarestech.com/temp/PDP2011/pdf/Business%20Model%20Generation%20\(1\).pdf](http://alvarestech.com/temp/PDP2011/pdf/Business%20Model%20Generation%20(1).pdf)
3. <https://www.getstoryshots.com/books/the-lean-startup-summary/>
4. <https://www.strategyzer.com/canvas>

Activity Based Learning (Suggested Activities in Class)

1. Real world problem solving with on field exposure.
2. Build Start-up and test the solution with real customers.

BUSINESS ANALYTICS

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

SEMESTER – VII

Subject Code	: 23RA4705	Credits	: 03
Hours / Week	: 03	Total Hours	: 39 Hours
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This Course will enable students to: 1. Gain proficiency in utilizing Tableau as powerful tools for data visualization and analysis. 2. Acquire the ability to clean, preprocess, and transform raw data into a format suitable for visualization. 3. Develop a variety of visualizations using both basic and advanced techniques. 4. Understand how data visualization is applied in real-world engineering scenarios and various industries.			
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
Understanding the basics visualizing data, Connecting to data in Tableau. (Text Book-1: Chapter 1,2)			
UNIT – II			08 Hours
Moving beyond basic visualizations starting an adventure with calculation and parameters, leveraging level of detail calculations, diving deep with table calculations. (Text Book-1: Chapter 3,4,5,6)			
UNIT – III			07 Hours
Telling a data story with dashboards , visual analytics: Trends, clustering, Distributions and Forecasting. (Text Book-1: Chapter 8,9)			
UNIT – IV			08 Hours
Advanced Visualization Techniques , Dynamic Dashboards, exploring mapping and advanced geospatial features. (Text Book-1: Chapter 10, 11,12)			
UNIT – V			07 Hours

Understanding the tableau data model Joins, and blends, structuring messy data to work well in Tableau, Taming data with Tableau Prep. (Text Book-1: Chapter 14,15,16)		
Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply the fundamentals of Tableau and visualize data using various charts and dashboards.	L1
2	Interpret level of detail calculations effectively, and delve deeply into table calculations for comprehensive data analysis in Tableau.	L2
3	Create effective data visualizations using dashboards and advanced visual analytics techniques such as trend analysis, clustering, distribution analysis, and forecasting.	L2
4	Analyze advanced visualization techniques, geographic features, and mapping to create a dynamic dashboard for in-depth data analysis and presentation using Tableau.	L1
5	Apply the Tableau data model, perform joins and blends to organize complex data for appropriate Tableau analysis, and Tableau Prep for data cleaning and transformation.	L2

Mapping Levels of COs to POs / PSOs

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
CO-1	2	2	2	2	2	-	-	-	2	2	-	-	2	2	2
CO-2	2	2	2	2	2	-	-	-	2	2	-	-	2	2	2
CO-3	2	2	2	2	2	-	-	-	2	2	-	-	2	2	2
CO-4	2	2	2	2	2	-	-	-	2	2	-	-	2	2	2
CO-5	2	2	2	2	2	-	-	-	2	2	-	-	2	2	2

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Learning Tableau 2022: Create effective data visualizations, build interactive visual analytics, and improve your data storytelling capabilities 5th edition, by Joshua N Milligan.

REFERENCE BOOKS:

1. Mastering Tableau 2023 - Fourth Edition: Implement advanced business intelligence techniques, analytics, and machine learning models with Tableau 4th edition, by Marleen Meier.
2. Tableau For Dummies, 2nd Edition (For Dummies (Computer/tech)) 2nd edition, by Jack A. Hyman.

Activity Based Learning (Suggested Activities in Class)

1. Design and build a dashboard using multiple visualizations.

2. Analyze case studies involving complex data challenges.

Design Thinking [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Course Code	: 23RA4706	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Understand the Principles and Phases of Design Thinking. 2. Understand the key stages of Design Thinking: Empathize, Define, Ideate, Prototype, and Test. 3. Explain the concept of celebrating differences and how diversity enhances the design process. 4. Understand how feedback drives iteration in the design process and enhances solution effectiveness. 5. Develop skills to analyze and synthesize feedback from different sources to identify common patterns and key areas for improvement.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			08 Hours
An Insight to Learning Understanding the Learning Process, Kolb's Learning Styles, Assessing and Interpreting, Remembering Memory, Understanding the Memory process, Problems in retention, Memory enhancement techniques, Experience & Expression Understanding Emotions: Experience & Expression, Assessing Empathy, Application with Peers.			
UNIT – II			08 Hours
Basics of Design Thinking Definition of Design Thinking, need for Design Thinking, Objective of Design Thinking, Concepts & Brainstorming, Stages of Design Thinking Process (explain with examples) – Being Ingenious & Fixing Problem: Empathize, Define, Ideate, Prototype, Test, Understanding Creative thinking process, Understanding Problem Solving, Testing Creative Problem Solving.			
UNIT – III			08 Hours
Process of Product Design Process of Engineering Product Design, Design Thinking Approach, Stages of Product Design, Examples of best product designs and functions, Assignment – Engineering Product Design. Prototyping & Testing: Prototype and its need, Rapid Prototype Development process, Testing, Sample Example, Test Group Marketing			
UNIT – IV			8 Hours
Celebrating the Difference Understanding Individual differences & Uniqueness Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences. Design Thinking & Customer Centricity: Practical			

Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design.

UNIT – V

7 Hours

Feedback, Re-Design & Re-Create

Feedback loop, Focus on User Experience, Address “ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – “Solving Practical Engineering Problem through Innovative Product Design & Creative Solution”.

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the key principles, processes, and frameworks of design thinking and its role in problem-solving and innovation.	L1
2	Demonstrate the ability to empathize with users and stakeholders by identifying their needs, challenges, and goals through effective research techniques.	L1
3	Apply brainstorming and ideation techniques to generate innovative and user-centered solutions to identified problems.	L2
4	Develop low-fidelity and high-fidelity prototypes to test and visualize potential solutions for user feedback.	L6
5	Develop a mindset that embraces experimentation, learning from failure, and continuous improvement in the design process.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Suggested Text Books: (i) Den Dekker Teun, “Design Thinking”, Wolters-Noordhoff B.V., Dec, 2020.
2. Pavan Soni, “Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem-solving”, Penguin Random House India Private Limited, 23 December 2020.

REFERENCE BOOKS:

1. Prof. Karl Ulrich, U. Penn, "Design: Creation of Artifacts in Society by Change", Oct, 2012.
2. Tim Brown, "Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation", Kindle edition, 2009

PROFESSIONAL ELECTIVE COURSE -IV

INDUSTRIAL ROBOTICS [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Course Code	: 23RA4707	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. Differentiate between automation and robotics. 2. Classify robots and describe its anatomy. 3. Specify various types of industrial sensors. 4. Classify various grippers. 5. Discuss about motion analysis of robot			
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 the traditional lecture method but a different type of teaching method that 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 clips 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. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the student's understanding.			
UNIT – I			08 Hours
Introduction to Robotics Introduction: Automation and robotic, an over view of robotics, classification by coordinate system and control systems; Components of the industrial robotics: Degrees of freedom, end effectors: Mechanical gripper, magnetic, vacuum cup and other types of grippers, general consideration on gripper selection and design.			
UNIT – II			08 Hours
Motion Analysis and Kinematics Motion analysis: Basic rotation matrices, composite rotation matrices, Euler angles, equivalent angle and axis, homogeneous transformation, problems; Manipulator kinematics: D-H notations, joint coordinates and world coordinates, forward and inverse kinematics, problems.			
UNIT – III			08 Hours
Kinematics and Dynamics Differential kinematics: Differential kinematics of planar and spherical manipulators, Jacobians problems. Robot dynamics: Lagrange, Euler formulations, Newton-Euler formulations, problems on planar two link manipulators			
UNIT – IV			8 Hours
Trajectory Planning and Actuators Trajectory planning: Joint space scheme, cubic polynomial fit, avoidance of obstacles, types of motion: Slew motion, joint interpolated motion, straight line motion, problems, Robot actuators and feedback components; Actuators: pneumatic and hydraulic actuators.			

UNIT - V	7 Hours
Electric Actuators and Robotic Applications Electric actuators: DC servo motors, stepper motors, feedback components: position sensors, potentiometers, resolvers and encoders, velocity sensors, tactile sensor; Robot application in manufacturing: Material handling, assembly and inspection.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Recall the characteristic features of robots and usage of different grippers for industrial applications.	L2
2	Comprehend direct and inverse kinematics of robot structure.	L3
3	Demonstrate differential Kinematics of planar and spherical manipulators.	L4
4	Analyze classification of robot actuators and trajectory planning	L4
5	Assess material handling and applications in manufacturing.	L5

Mapping Levels of COs to POs / PSOs

Table: Mapping Levels of COs to POs / PSOs															
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CO-2	3	3	2	-	1	-	-	-	2	2	-	-	2	2	-
CO-3	3	3	2	1	-	1	-	-	-	2	2	-	2	1	-
CO-4	3	1	-	-	1	-	-	-	2	2	-	2	2	2	-
CO-5	2	1	3	-	1	-	-	-	2	2	-	2	1	1	-
3: Substantial (High)				2: Moderate (Medium)								1: Poor (Low)			

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Yan, Lili, and Gene M. Grossman. Robots and AI: A new economic era. Taylor & Francis, 2023.
2. Niku, Saeed B. Introduction to robotics: analysis, control, applications. John Wiley & Sons, 2020.

REFERENCE BOOKS:

1. Groover M. P, "Industrial Robotics", TataMcGraw-Hill, 1 st Edition, 2013
2. Richard D. Klafter, "Robotic Engineering", Prentice Hall, 1st Edition, 2013.
3. Fu K S, "Robotics", McGraw-Hill, 1st Edition, 2013.

E-Resources:

1. <https://www.doc.ic.ac.uk/~ajd/Robotics/RoboticsResources/lecture1.pdf>
2. <http://opencourses.emu.edu.tr/course/view.php?id=32>
3. https://www.researchgate.net/publication/277712686_Introduction_to_Robotics_class_notes_UG_level

Activity Based Learning (Suggested Activities in Class)

1. Group discussion.
2. Projects on Computer graphics & User interface design.
3. Quiz
4. Assignment

MULTILINGUAL SPEECH & LANGUAGE PROCESSING [As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Course Code	: 23RA4708	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: 1. To understand basics of linguistics, probability and statistics. 2. To study statistical approaches to NLP and understand sequence labeling. 3. To outline different parsing techniques associated with NLP. 4. To explore semantics of words and semantic role labeling of sentences. 5. To understand discourse analysis, question answering and chatbots.			
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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. <i>Showing Video/animation films to explain functioning of various concepts.</i> 4. <i>Encourage Collaborative</i> (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			08 Hours
Introduction Natural Language Processing – Components - Basics of Linguistics and Probability and Statistics – Words-Tokenization-Morphology-Finite State Automata.			
UNIT – II			08 Hours
Statistical NLP and Sequence Labeling N-grams and Language models –Smoothing -Text classification- Naïve Bayes classifier – Evaluation - Vector Semantics – TF-IDF - Word2Vec- Evaluating Vector Models -Sequence Labeling – Part of Speech – Part of Speech Tagging -Named Entities –Named Entity Tagging.			
UNIT – III			08 Hours
Contextual Embedding Constituency –Context Free Grammar –Lexicalized Grammars- CKY Parsing – Earley's algorithm Evaluating Parsers -Partial Parsing – Dependency Relations- Dependency Parsing -Transition Based - Graph Based.			
UNIT – IV			08 Hours
Computational Semantics Word Senses and WordNet – Word Sense Disambiguation – Semantic Role Labeling – Proposition Bank-FrameNet- Selectional Restrictions - Information Extraction - Template Filling.			

UNIT – V	07 Hours
Discourse Analysis and Speech Processing Discourse Coherence – Discourse Structure Parsing – Centering and Entity Based Coherence – Question Answering – Factoid Question Answering – Classical QA Models – Chatbots and Dialogue systems – Frame-based Dialogue Systems – Dialogue–State Architecture.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Understand basics of linguistics, probability and statistics associated with NLP.	L1
2	Implement a Part-of-Speech Tagger.	L1
3	Design and implement a sequence labeling problem for a given domain.	L2
4	Implement semantic processing tasks and simple document indexing and searching system using the concepts of NLP.	L6
5	Implement a simple chatbot using dialogue system concepts.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition" (Prentice Hall Series in Artificial Intelligence), 2020.
2. Jacob Eisenstein. "Natural Language Processing ", MIT Press, 2019.

REFERENCE BOOKS:

1. Samuel Burns "Natural Language Processing: A Quick Introduction to NLP with Python and NLTK, 2019.
2. Christopher Manning, "Foundations of Statistical Natural Language Processing", MIT Press, 2009.
3. Nitin Indurkha, Fred J. Damerau, "Handbook of Natural Language Processing", Second edition, Chapman & Hall/CRC: Machine Learning & Pattern Recognition, Hardcover, 2010.
4. Deepti Chopra, Nisheeth Joshi, "Mastering Natural Language Processing with Python", Packt Publishing Limited, 2016.

5. Mohamed Zakaria Kurdi "Natural Language Processing and Computational Linguistics: Speech, Morphology and Syntax (Cognitive Science)", ISTE Ltd., 2016.

EMBEDDED SYSTEMS

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

SEMESTER – VII

Course Code	: 23RA4709	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P	: 3-0-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This course will enable students to:

1. To **study** fundamental concepts of Embedded Systems.
2. To **understand** the role of Devices and communication buses for devices network.
3. To **Learn** about device drivers and service mechanism.
4. To be **familiar** with Inter process communication and synchronization of processes, Threads and tasks.
5. **Appreciate** the role of Real-time operating systems.
6. **Understand** the role of Embedded 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:

1. **Lecture method** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching:** incorporating brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I

08 Hours

Introduction to Embedded Systems

Embedded systems, Processor embedded into a system, Embedded hardware units and device in a system, Embedded software in a system, Examples of embedded systems. Design process in embedded system, Formalization of system design, Design process and design examples, Classification of embedded systems, skills required for an embedded system designer.

UNIT – II

08 Hours

Devices and Communication Buses for Devices Network

IO types and example, Serial communication devices, Parallel device ports, Sophisticated interfacing features in device ports. Wireless devices, Timer and counting devices, Watchdog timer, Real time clock, Networked embedded systems. Serial bus communication protocols, Parallel bus device protocols-parallel communication internet using ISA, PCI, PCI-X and advanced buses, Internet enabled systems network protocols, Wireless and mobile system protocols.

UNIT – III

08 Hours

Device Drivers and Interrupts and Service Mechanism

Programming-I/O busy-wait approach without interrupt service mechanism, ISR concept, Interrupt sources, Interrupt servicing (Handling) Mechanism, Multiple interrupts, Context and the periods for context switching, interrupt latency and deadline, Classification of processors interrupt service mechanism from Context-saving angle, Direct memory access, Device driver programming.

UNIT – IV	08 Hours
Inter Process Communication and Synchronization of Processes, Threads and Tasks Multiple process in an application, Multiple threads in an application, Tasks, Task states, Task and Data, Clear-cut distinction between functions. ISRS and tasks by their characteristics, concept and semaphores, Shared data, Inter process communication, Signal function, Semaphore functions, Message Queue functions, Mailbox functions, Pipe functions, Socket functions, RPC functions.	
UNIT – V	07 Hours
Real-time Operating Systems OS Services, Process management, Timer functions, Event functions, Memory management, Device, file and IO subsystems management, Interrupt routines in RTOS environment and handling of interrupt source calls. Real-time operating systems, Basic design using an RTOS, RTOS task scheduling models, interrupt latency and response of the tasks as performance metrics, OS security issues. Introduction to embedded software development process and tools, Host and target machines, Linking and location software.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Elucidate the Basic concepts, terminologies and architecture of Embedded systems.	L1
2	Analyze the role of real-time operating systems in embedded systems and apply multitasking concepts for system design.	L1
3	Solve real-world problems by designing embedded solutions for various domains such as IoT, robotics, healthcare, and automotive systems.	L2
4	Work collaboratively in teams to design and implement embedded projects, effectively communicating technical concepts.	L6
5	Illustrate the working of Real-time operating systems and understand the embedded software development process	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

- Wayne Wolf: Computers as Components, Principles of Embedded Computing Systems Design, 2nd Edition, Elsevier, 2008.
- Shibu K V: Introduction to Embedded Systems, Tata McGraw Hill, 2009 (Chapters 10, 13)

Reference Books:

1. James K. Peckol: Embedded Systems, A contemporary Design Tool, Wiley India, 2008
2. Tammy Neorgaard: Embedded Systems Architecture, Elsevier, 2005.

Activity Based Learning (Suggested Activities in Class)

1. Assignments (in writing and doing forms on the aspects of syllabus content and outside
2. the syllabus content. Shall be individual and challenging)
3. Student seminars (on topics of the syllabus and related aspects (individual activity)
4. Quiz (on topics where the content can be compiled by smaller aspects and data
 - a. (Individuals or groups as teams))
5. Study projects (by very small groups of students on selected local real-time problems
 - a. pertaining to syllabus or related areas. The individual participation and contribution of
 - b. students shall be ensured (team activity))

AUTONOMOUS VEHICLES	
[As per Choice Based Credit System (CBCS) scheme]	
SEMESTER – VII	
Course Code : 23RA4710	Credits : 03
Hours / Week : 03	Total Hours : 39
L-T-P-J : 3-0-0-0	CIE+SEE : 60+40 Marks
Course Objectives: This course will enable students to: 1. To apply the concepts, technologies, and components of Advanced Driving Assistance Systems 2. To make use of a knowledge of sensors, planning, and control algorithms for autonomous vehicles 3. To determine the operating system reliability and security of client systems in ADAS 4. To discover the cloud platform architecture and services used with ADAS technology 5. To improve the practical experience in developing ADAS components and evaluating their 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 along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. 2. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying. 3. Showing Video/animation films to explain functioning of various concepts. 4. Encourage Collaborative (Group Learning) Learning in the class. 5. To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. 6. Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.	
UNIT – I	07 Hours
Introduction to Autonomous Driving Autonomous Driving Technologies Overview, Autonomous Driving Algorithms, Autonomous Driving Client System: Robot Operating System, Hardware Platform, Autonomous Driving Cloud Platform: Simulation, HD Map Production.	
UNIT – II	08 Hours
Autonomous Vehicle Localization, Prediction, And Routing Localization with GNSS, Localization with LiDAR and High-definition maps, Planning and Control in a broader sense, Traffic prediction introduction, Lane Level Routing: Constructing a weighted directed graph for routing, Typical Routing Algorithms.	
UNIT – III	08 Hours
Autonomous driving A complex system, Operating System for Autonomous Driving, System Reliability, Resource Management and Security, Computing Platform, Computer Architecture Design Exploration.	
UNIT – IV	9 Hours
Cloud Platform for Autonomous Driving Introduction, Infrastructure, Distributed Computing Framework, Distributed Storage, Heterogeneous Computing, Simulation, HD Map generation.	

UNIT - V	7 Hours
Case Study Applications/design requirements specifications of Autonomous vehicles (Aerial, under water, ground vehicles), Unmanned aerial vehicles, Google self-driving cars.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	To utilize the principles and technologies behind autonomous driving and advanced driver assistance systems	L3
2	To develop a solid understanding of localization, prophecy, and routing algorithms used in autonomous vehicles	L6
3	To survey the client's complex system and safety considerations involved in autonomous driving.	L4
4	To evaluate the distributed infrastructure with relevant software tools and simulation environments for autonomous driving.	L5
5	To analyze the various application and design requirements of autonomous driving technology	L4

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot, "Creating Autonomous Vehicle Systems", Morgan and Claypool, 2018.
2. Hong Cheng, "Autonomous Intelligent Vehicles Theory, Algorithms, and Implementation", Springer, 2011

REFERENCES BOOKS:

1. Hermann Winner, Stephan Hakuli, Felix Lotz, Christina Singer, "Handbook of Driver Assistance Systems - Basic Information, Components and Systems for Active Safety and Comfort", Springer Reference
2. Umit Ozguner, Tankut Acarman, Keith Redmill, "Autonomous Ground Vehicles", Artech House, 2011.
3. Mohinder S. Grewal, Angus P. Andrews, Chris G. Bartone, "Global Navigation Satellite Systems, Inertial Navigation, and Integration", Third Edition, John Wiley and Sons, 2013.

Professional Elective Course – V

SOFT ROBOTICS			
[As per Choice Based Credit System (CBCS) scheme]			
SEMESTER – VII			
Course Code	: 23RA4711	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P	: 3-0-0-0	CIE+SEE	: 60+40 Marks
Course Objectives: This course will enable students to: Understand the principles and key differences between soft robotics and traditional rigid robotics. Explore the role of soft materials in creating adaptive, flexible, and compliant robotic systems. Identify and understand soft materials (e.g., elastomers, hydrogels, and shape-memory polymers) commonly used in soft robotics. Learn about fabrication methods, including 3D printing, casting, and molding techniques.			
Teaching-Learning Process (General Instructions) These are sample new pedagogical methods, where teachers can use to accelerate the attainment of the various course outcomes: Lecture method along with traditional lecture method, different <i>type of teaching methods</i> may be adopted to develop the course outcomes. Interactive Teaching: <i>incorporating</i> brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and role playing. - Showing Video/animation films to explain functioning of various concepts. - Encourage Collaborative (Group Learning) Learning in the class. - To make Critical thinking, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions. - Showing the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.			
UNIT – I			08 Hours
High-Performance Soft Wearable Robots for Human Augmentation and Gait Rehabilitation Introduction, Actuation technologies for physical human robot interaction, Applications to wearable robots.			
UNIT – II			08 Hours
Development of different types of ionic polymer metal composite-based soft actuators for robotics and biomimetic applications Introduction, Literature survey on IPMC as actuators and sensors and its applications, Development of IPMC base soft actuator by different approaches, Results and discussions, Development of robotic system using different types of IPMC actuators			
UNIT – III			08 Hours
Soft Microrobots Based on Photo responsive Materials Soft Robotics at the Micro Scale, LCEs for Micro-robotics, Thermal Response of LCEs, Photothermal Actuation of LCEs, Light-Controlled Soft Microrobots, Structured Light, Controlled Actuation, Role of Control Parameters, Swimming Microrobots.			
UNIT – IV			08 Hours
4D Printing: An Enabling Technology for Soft Robotics Introduction, 3D Printing Techniques, Material Extrusion-Based Techniques, Vat Photopolymerization Techniques, 4D Printing of Responsive Materials, Shape Memory Polymers, Hydrogels, Liquid Crystalline Elastomers, 4D Printing Toward Soft Robotics.			

UNIT – V	07 Hours
Biohybrid Robot Powered by Muscle Tissues Introduction, Muscle Usable in Biohybrid Robots, Cardiomyocyte and Cardiac Muscle Tissue, Skeletal Muscle Fiber and Skeletal Muscle Tissue, Cell and Tissue Other Than Mammals, Actuation of Biohybrid Robots Powered by Muscle, Biohybrid Robot with a Single Muscle Cell, Biohybrid Robot with Monolayer of Muscle Cells, Biohybrid Robot with Muscle Tissues.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain the fundamental differences between soft and rigid robotics, including the advantages and challenges of soft robotic systems.	L1
2	Evaluate and select appropriate soft materials for specific soft robotic applications based on their mechanical and chemical properties.	L1
3	Demonstrate proficiency in soft robotics fabrication methods, such as casting, molding, and 3D printing, to construct functional prototypes.	L2
4	Demonstrate an understanding of the ethical and sustainability considerations in the design and deployment of soft robots.	L6
5	Investigate and present current research and emerging trends in soft robotics, demonstrating the ability to stay updated with advances in the field.	L1

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

- Wayne Wolf: Computers as Components, Principles of Embedded Computing Systems Design, 2nd Edition, Elsevier, 2008.
- Shibu K V: Introduction to Embedded Systems, Tata McGraw Hill, 2009. (Chapters 10, 13)

REFERENCE BOOKS:

1. James K. Peckol: Embedded Systems, A contemporary Design Tool, Wiley India, 2008
2. Tammy Neorgaard: Embedded Systems Architecture, Elsevier, 2005.

Activity Based Learning (Suggested Activities in Class)

1. Assignments (in writing and doing forms on the aspects of syllabus content and outside
2. the syllabus content. Shall be individual and challenging)
3. Student seminars (on topics of the syllabus and related aspects (individual activity)
4. Quiz (on topics where the content can be compiled by smaller aspects and data
 - a. (Individuals or groups as teams))
5. Study projects (by very small groups of students on selected local real-time problems
 - a. pertaining to syllabus or related areas. The individual participation and contribution of
 - b. students shall be ensured (team activity))

FUNDAMENTALS OF VIRTUAL REALITY AND APP DEVELOPMENT

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

SEMESTER – VII

Subject Code : 23RA4712	Credits : 03
Hours / Week : 03	Total Hours : 39
L-T-P-J : 3-0-0-0	CIE+SEE : 60+40 Marks

Course Objectives:

This Course will enable students to:

1. To **gain** the knowledge of historical and modern overviews and perspectives on virtual reality.
2. To **learn** the fundamentals of sensation, perception, and perceptual training.
3. To have the scientific, technical, and engineering aspects of augmented and virtual reality systems.
4. To **learn** the Evaluation of virtual reality from the lens of design.
5. To **learn** the technology of augmented reality and implement it to have practical knowledge.

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 methods, but different *types of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching: Adopt the Active learning** that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, 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
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INTRODUCTION

Introduction to Augmented-Virtual and Mixed Reality, Taxonomy, technology and features of augmented reality, difference between AR, VR and MR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality.

UNIT – II	09 Hours
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VR System

VR as a discipline, Basic features of VR systems, Architecture of VR systems, VR hardware: VR input hardware: tracking systems, motion capture systems, data gloves, VR output hardware: visual displays.

UNIT – III	08 Hours
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VR Software Development

Challenges in VR software development, Master/slave and Client/server architectures, Cluster rendering, Game Engines and available sdk to develop VR applications for different hardware (HTC VIVE, Oculus, Google VR).

UNIT – IV	07 Hours
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AR Software Development

AR software, Camera parameters and camera calibration, Marker-based augmented reality, AR Toolkit

UNIT - V	07 Hours
Application Application of VR in Digital Entertainment: VR Technology in Film & TV Production. VR Technology in Physical Exercises and Games. Demonstration of Digital Entertainment by VR.	

Course completion Capstone project not limited to the following ideas:

1. AR/VR Gaming Experience
2. Virtual Tour of Historical Sites or Landmarks

Course Outcomes

Course Outcomes (Cos)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Identify , examine, and develop software that reflects fundamental techniques for the design and deployment of VR and AR experiences.	L2, L3
2	Describe how VR and AR systems work.	L5
3	Choose, develop, explain, and defend the use of particular designs for AR and VR experiences.	L2
4	Evaluate the benefits and drawbacks of specific AR and VR techniques on the human body.	L2
5	Identify and examine AR and VR design problems and solutions from the industry and academia.	L2, L3

Mapping Levels of COs to POs / PSOs

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
CO-1	2	3	2	-	-	-	-	-	-	-	-	2	3	1	1
CO-2	2	2	3	-	-	-	-	-	-	-	-	2	2	3	3
CO-3	2	3	2	-	-	-	-	-	-	-	-	2	3	1	3
CO-4	1	2	3	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	2	1	3	-	-	-	-	-	-	-	-	2	2	3	3

TEXT BOOKS:

1. George Mather, Foundations of Sensation and Perception: Psychology Press; 2 edition, 2009
2. The VR Book: Human-Centered Design for Virtual Reality, by Jason Jerald
3. Learning Virtual Reality by Tony Parisi, O' Reilly
4. Burdea, G. C. and P. Coffet. Virtual Reality Technology, Second Edition. Wiley-IEEE Press, 2003/2006.
5. Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, Morgan Kaufmann, 2013.

REFERENCE BOOKS:

1. Alan Craig, William Sherman and Jeffrey Will, Developing Virtual Reality Applications, Foundations of Effective Design, Morgan Kaufmann, 2009.

E-Resources:

1. <http://msl.cs.uiuc.edu/vr/>
2. Unity Learn: <https://learn.unity.com/>
3. Coursera: <https://www.coursera.org/>
4. Oculus Developer Center: <https://developer.oculus.com/>

Activity Based Learning (Suggested Activities in Class)

1. AR/VR Prototyping.
2. AR/VR Immersive Experiences

INTRODUCTION TO QUANTUM COMPUTING

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

SEMESTER – VII

Subject Code	: 23RA4713	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P-J	: 3-0-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This Course will enable students to:

1. **Explain** the basic concepts of quantum computation and its physics.
2. **Use** various **operators** of quantum computation and work on quantum transformation.
3. **Illustrate** the working of some standard quantum algorithms.
4. **Analyze** the complexities involved in working of quantum algorithms.

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, 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 analyze 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

FUNDAMENTAL CONCEPTS

Global Perspectives, Quantum Bits, Quantum Computation, Quantum Algorithms, Quantum Information, (PART I, Chapter : 1.1, 1.2, 1.3, 1.4, 1.6 Pg. No. 01). Postulates of Quantum Mechanisms. (Chapter 2: 2.2 Pg. No.80)

UNIT – II

07 Hours

QUANTUM COMPUTATION

Quantum Circuits – Quantum algorithms, Single Orbit operations, Control Operations, Measurement, Universal Quantum Gates, Simulation of Quantum Systems, (PART II, Chapter 4: 4.1, 4.2, 4.3, 4.4, 4.5, 4.7, Pg. No. 171). Quantum Fourier transform, Phase estimation, Applications, (Chapter 5: 5.1, 5.2, 5.3) Quantum search algorithms – Quantum counting– Speeding up the solution of NP – complete problems – Quantum Search for an unstructured database. (Chapter 6: 6.1, 6.3, 6.4, 6.5)

UNIT – III

08 Hours

QUANTUM COMPUTERS

Guiding Principles, Conditions for Quantum Computation, Harmonic Oscillator Quantum Computer, Optical Photon Quantum Computer – Optical cavity Quantum electrodynamics, Ion traps, Nuclear Magnetic resonance. (Chapter 7: 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7)

UNIT – IV

09 Hours

QUANTUM INFORMATIONS

Quantum noise and Quantum Operations – Classical Noise and Markov Processes, Quantum Operations, Examples of Quantum noise and Quantum Operations – Applications of Quantum operations, Limitations of the Quantum operations formalism, (PART III, Chapter 8: 8.1, 8.2, 8.3, 8.4, 8.5 Pg. No. 353) Distance

Measures for Quantum information. (Chapter 9: 9.1, 9.2, 9.3 Pg. No. 399)	
UNIT – V	08 Hours
QUANTUM ERROR CORRECTION Introduction, Shor code, Theory of Quantum Error –Correction, Constructing Quantum Codes, Stabilizer codes, Fault – Tolerant Quantum Computation, (Chapter 10: 10.1, 10.2, 10.3, 10.4, 10.5, 10.6 Pg. No. 425). Entropy and information – Shannon Entropy, Basic properties of Entropy, Von Neumann, Strong Sub Additivity, (Chapter 11: 11.1, 11.2, 11.3, 11.4 Pg. No. 500) Data Compression, Entanglement as a physical resource. (Chapter 12: 12.2, 12.5)	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Explain basic concepts in Quantum computing.	L1
2	Illustrate applications of Quantum computing.	L2
3	Explain principles in the design of Quantum Computers.	L1
4	Analyze applications and limitations of Quantum operations.	L4
5	Apply concepts in Quantum Error Correction.	L3

Mapping Levels of COs to POs / PSOs

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		2	3
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Michael A. Nielsen. & Issac L. Chiang, "Quantum Computation and Quantum Information", South Asia Edition 2013, Cambridge University Press, Reprint 2022.

REFERENCE BOOKS:

1. "Quantum Computing, A Gentle Introduction", Eleanor G. Rieffel and Wolfgang H. Polak MIT press (2014).
2. Mikio Nakahara and Tetsuo Ohmi, "Quantum Computing", CRC Press (2008).
3. N. David Mermin, "Quantum Computer Science", Cambridge (2007).
3. An introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, Michele Mosca, Oxford University Press, 2007, ISBN-13: 978-0198570493, ISBN-10: 019857049X.

E-Resources:

1. <https://nptel.ac.in/courses/106106232>
2. <https://www.youtube.com/watch?v=teraaPiaG8s>

Activity Based Learning (Suggested Activities in Class):

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

ROBOTICS IN MANUFACTURING

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

SEMESTER – VII

Course Code	: 23RA4714	Credits	: 03
Hours / Week	: 03	Total Hours	: 39
L-T-P	: 3-0-0-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This course will enable students to:

1. **Understanding** of the fundamental principles of robotics.
2. **Analyze** the role of robotics in modern manufacturing, emphasizing automation, productivity, and quality enhancement.
3. To **understand** and implement control systems for robot operation, including motion planning and path optimization.
4. To **understand** criteria for selecting and designing robotic systems tailored to manufacturing requirements.
5. To **explore** advancements in robotics, such as collaborative robots (cobots), artificial intelligence, machine learning, and IoT integration in manufacturing.

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** along with traditional lecture method, different *type of teaching methods* may be adopted to develop the course outcomes.
2. **Interactive Teaching:** *incorporating* brainstorming, discussing, group work, focused listening, formulating questions, note-taking, annotating, and roleplaying.
3. Showing **Video/animation** films to explain functioning of various concepts.
4. Encourage **Collaborative** (Group Learning) Learning in the class.
5. To make **Critical thinking**, asking Higher order Thinking questions in the class in the form of Quiz and writing programs with complex solutions.
6. Showing the **different ways to solve** the same problem and encourage the students to come up with their own creative ways to solve them.

UNIT – I	08 Hours
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Role of Machine Vision in Manufacturing and Industrial Revolution

Introduction, Industrial Revolutions, Smart Technologies in Manufacturing, Machine Vision Concept and Definitions, Basic Concepts Related to Machine Vision, Applications of Machine Vision, Components and Features of Machine Vision, Differences Between Computer Vision And Machine Vision Technology, Application Areas Of Machine Vision, Future Of Machine Vision

UNIT – II	08 Hours
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Application of Robotics in Manufacturing Industry

Robotics In Manufacturing, Importance Of Robotics In Enhancing Efficiency And Productivity, Evolution Of Robotics In Manufacturing And Its Impact On The Industry, Robotic Applications In Assembly, Robotic Applications In Material Handling, Robotic Applications In Quality Control And Inspection, Robotic Applications In Packaging And Palletizing, Robotic Applications In Welding And Cutting, Robotic Applications In Hazardous Environments, Future Trends And Emerging Applications In Robotics: Robotics In Industry 4.0 And Smart Manufacturing, Advances In Artificial Intelligence And Machine Learning For Robotics, Advances In Blockchain For Robotics, Potential Future Applications And Innovations In Robotics.

UNIT – III	08 Hours
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Application of Industrial Robotics in Manufacturing

Introduction, Features and Types of Robots, Application Areas of Robots, Overview of Industrial Robots, Types of Industrial Robots, Robotics and Manufacturing, Future of Robotics in Manufacturing.

UNIT – IV	8 Hours
Enabling the Future of Manufacturing - Integration of Robotics and IoT into Smart Factory Infrastructure in Industry Introduction, role of IOT in smart factory infrastructure in industry 4.0, human-robot collaboration and IOT in smart factory for manufacturing and business, human-robot collaboration and IOT in smart laptop assembly factory, decision-making mathematical model for manufacturing better laptop products, advantages of integration of robotics, IOT, and smart factory	
UNIT – V	7 Hours
Application of Artificial Intelligence and Internet of Things in the Manufacturing Sector Introduction, Internet of Things and Artificial Intelligence, AIot Architecture, AIot Applications, AIot in Manufacturing.	

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Demonstrate a solid understanding of the principles of robotics, including kinematics, dynamics, and control systems, as they apply to manufacturing processes.	L1
2	Apply engineering principles to design, analyze, and integrate robotic systems into manufacturing environments, considering factors such as efficiency, precision, and safety.	L2
3	Evaluate and implement automation technologies, including sensors, actuators, and controllers, to optimize manufacturing operations.	L1
4	Develop and execute programs for robotic manipulators and autonomous systems using relevant programming languages and platforms.	L4
5	Analyze and optimize the use of robotic systems for various manufacturing tasks, such as welding, assembly, material handling, and quality inspection.	L3

Mapping Levels of COs to POs / PSOs

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
CO-1	3	2	2	-	-	-	-	-	-	-	-	2	2	2	1
CO-2	3	1	2	-	-	-	-	-	-	-	-	1	3	3	3
CO-3	3	-	2	-	1	-	-	-	-	-	-	1	2	3	3
CO-4	3	-	2	-	-	-	-	-	-	-	-	1	2	3	2
CO-5	3	-	2	-	-	-	-	-	-	3	-	1	2	3	3
3: Substantial (High)				2: Moderate (Medium)						1: Poor (Low)					

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
- **PSO-3:** Apply robotics and AI to solve real-world problems in a variety of domains, including industrial robotics, service robots, exoskeletons, surgical robots, delivery vehicles, autonomous vehicles, and crewless micro aerial vehicles.

TEXT BOOKS:

1. Alex Khang, Vugar Abdullayev Hajimahmud, Anuradha Misra, and Eugenia Litvinova, 'Machine Vision and Industrial Robotics in Manufacturing', CRC Press, Taylor & Francis Group.
2. **Mikell P. Groover**, "Automation, Production Systems, and Computer-Integrated Manufacturing", 5th Edition, Pearson, 2018.

REFERENCE BOOKS:

1. Gordon M. Mair, "Industrial Robotics", Prentice Hall, Reprint 2019.
2. Yoram Koren, "Computer Control of Manufacturing Systems", McGraw Hill, Reprint 2019.

VIII-Semester Syllabus

CAPSTONE PROJECT-PHASE II

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

SEMESTER – VIII

Subject Code	: 23RA4801	Credits	: 12
Hours / Week	: 24	Total Hours	: 312
L-T-P-J	: 0-0-0-24	CIE+SEE	: 60+40 Marks
Course Objectives: This Course will enable students to: Detailed design of the solution to the problem statement and project management using software engineering skills. Write efficient code and test the code to find any bugs and resolve the same leading to completion and deployment of the project using modern tools. Analyze and synthesize the project results. Demonstrate knowledge and understanding of writing the publication/report. Able to work in teams and present the project work.			
DESCRIPTION: - The problem statement selected in Major Project Phase-I (VII semester) will be carried in the VIII semester. - Phase-II comprises of the detailed design, implementation, and testing results during the internal and external review. - Each Project team needs to submit the technical paper or patent or participate in hackathons and project exhibitions as well as apply for various state and national funding agencies within the stipulated time frame by the university. - There will be CIA evaluation (Project reviews) done by a committee of senior faculty of the Department. - Additionally, there will be a Semester end evaluation of the work done that would include an internal Faculty and an external academic expert.			

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Conduct a survey of several available literature in the preferred field of study to find the recent advances and gaps.	L1
2	Implement the mathematics concept and engineering fundamentals, and specialization to design a solution using modern tools for the defined problem.	L2
3	Experimenting and evaluating the results from test data to provide a conclusion to the project work.	L1
4	Demonstrate an ability to work in teams and to prepare quality documents of project work & exhibit technical presentation skills.	L4
5	Conduct research to gather data, explore innovative approaches, and incorporate new ideas into the project.	L3

Mapping Levels of COs to POs / PSOs

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

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
- **PSO-2:** Develop AI-powered software systems to control and operate robotic systems.
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INTERNSHIP

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

SEMESTER – VIII

Subject Code	: 23RA4802	Credits	: 03
Hours / Week	: 06	Total Hours	: 78
L-T-P-J	: 0-0-6-0	CIE+SEE	: 60+40 Marks

Course Objectives:

This Course will enable students to:

1. To **expose** students to the industrial environment.
2. To **create** competent professionals for the industry.
3. To **provide** possible opportunities to learn, understand and sharpen the real time technical /managerial skills required at the job.
4. To **work** on a problem assigned by a mentor at industry, prepare action plan and complete within time limit.
5. To **learn**, create/prepare report for Project/research as used in industry with productive and efficient way.
6. To **strengthen** industry-institute linkage and increase employability of the students.

Guideline for Internship:

The course includes 16 weeks of on-job training on current industry-relevant problem through supervised self-learning approach. The internship is an individual activity. The student should obtain approval from the chairman/supervisor to pursue. A student shall submit a brief proposal about the work to be carried out in the internship, to a coordinator within 3 weeks, after starting the internship.

A comprehensive report is required to be prepared and submit to the department at the end of the semester. A certificate shall be attached with this report duly signed by the competent authority of the industry for the successful completion of the internship. An attendance report shall also be attached with this report. The CIA evaluation will be done by faculty mentor or Industry Supervisor. There is no SEE Exam for this course.

Course Outcomes

Course Outcomes (COs)	Description	Bloom's Taxonomy Level
1	Understand the modern tools used in the field of Computer science and engineering for product development.	L2
2	Demonstrate ethical conduct and professional accountability while working in a team for the benefit of society.	L2
3	Understand the resources requirement and planning to facilitate the project success.	L3
4	Develop and refine oral and written communication skills.	L3
5	Demonstrate knowledge of the industry in which the internship is done.	L3

Mapping Levels of COs to POs / PSOs

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
CO-1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	-
CO-2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	-
CO-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

3: Substantial (High)

2: Moderate (Medium)

1: Poor (Low)

- **PSO-1:** Design and build robotic systems for different applications using analytical, logical, and problem-solving skills.
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