

Zeal Education Society's
ZEAL COLLEGE OF ENGINEERING & RESEARCH, PUNE – 41
(An Autonomous Institute Affiliated to Savitribai Phule Pune University)
NAAC Accredited with A+ Grade / ISO 21001:2018



DEPARTMENT OF ROBOTICS AND AUTOMATION
Curriculum Structure and Syllabus of
T.Y. B. Tech. – Robotics and Automation Engineering

(With effect from - Academic Year 2026- 27)

VISION OF THE INSTITUTE

To be a premier institute in technical education by imparting academic excellence, research,
social and entrepreneurial attitude

MISSION OF THE INSTITUTE

- To achieve academic excellence through innovative teaching and learning process.
 - To imbibe the research culture for addressing industry and societal needs.
 - To inculcate social attitude through community engagement initiatives.
 - To provide conducive environment for building the entrepreneurial skills.

DEPARTMENT OF ROBOTICS AND AUTOMATION

VISION:

To be recognized as a multidisciplinary department and build skilled professionals by imparting quality technical education and inculcating problem solving and lifelong learning skills through project-based approach in collaboration with industries in the field of Robotics & Automation.

MISSION:

- M1:** To impart quality technical education in Robotics and Automation Engineering.
- M2:** To inculcate sustainable skills in automation technologies, research and learning attitudes, and social responsibilities.
- M3:** To be committed to fulfill the needs of society in the Robotics & Automation industries.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

- PEO1:** Robotics & Automation Engineering graduates excel in solving industrial challenges, innovating for society, and leveraging core engineering principles for industry advancement.
- PEO2:** Graduates will apply technical expertise, leadership, and entrepreneurship, to establish ethical organizations to address societal needs and pursue higher studies.
- PEO3:** Graduates will work effectively as individuals and as team members with high ethical values and motivation for life-long learning for the benefit of society.

PROGRAM OUTCOMES (POs):

- PO1: Engineering knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
- PO2: Problem analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development, (WK1 to WK4).
- PO3: Design/development of solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
- PO4: Conduct investigations of complex problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
- PO5: Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems, (WK2 and WK6).

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- PO6: The Engineer and Word:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment, (WK1, WK5, and WK7).
- PO7: Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9).
- PO8: Individual and team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
- PO9: Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.
- PO10: Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
- PO11: Life-long learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) Critical thinking in the broadest context of technological change. (WK8).

PROGRAM SPECIFIC OUTCOMES (PSOs):

- PSO1:** Design and Development of robotic systems that are cost-effective, environment friendly to solve engineering and societal problems using advanced tools and techniques.
- PSO2:** Model, program and build error-free, safe, and productive automation systems for various manufacturing processes.
- PSO3:** Apply domain knowledge of robotics and automation to provide solutions in interdisciplinary areas to meet current industrial challenges.

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LIST OF ABBREVIATIONS

Abbreviation	Description
BSC	Basic Science Course
ESC	Engineering Science Course
PCC	Program Core Course
PEC	Program Elective Course
MDM	Multidisciplinary Minor
OE	Open Elective - Other than a particular program
VSEC	Vocational and Skill Enhancement Course
AEC	Ability Enhancement Course
ENTR	Entrepreneurship
EC	Economics
MC	Management Courses
IKS	Indian Knowledge System
VEC	Value Education Courses
RM	Research Methodology
CEP	Community Engagement Project
FP	Field Project
PROJ	Project
INT	Internship
OJT	On Job Training
CC	Co-curricular Courses
HSSM	Humanities Social Science and Management
ELC	Experiential Learning Course
B. Tech	Bachelor of Technology
L	Lecture
P	Practical
T	Tutorial
H	Hours
CR	Credits
CIE	Continuous Internal Evaluation
ETE	End Term Evaluation
TW	Term Work
OR	Oral
PR	Project

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STRUCTURE

Third Year B. Tech. – Robotics & Automation: Semester - V

Course Code	Course Type	Course Name	Teaching Scheme (Hrs./Week)							Evaluation Scheme					
			L	P	T	H	CR			CIE	ETE	TW	PR	OR	Total
							TH	PR/Tut	Total						
RAPC508	PCC	Industrial Hydraulics & Pneumatics	3	-	-	3	3	-	3	40	60	-	-	-	100
RAPC508P	PCC	Industrial Hydraulics & Pneumatics Lab	-	2	-	2	-	1	1	-	-	-	25	-	25
RAPC509	PCC	Design of Robot Elements	3	-	-	3	3	-	3	40	60	-	-	-	100
RAPC509P	PCC	Design of Robot Elements Lab	-	2	-	2	-	1	1	-	-	-	-	25	25
RAPC510	PCC	Embedded System in Robotics	3	-	-	3	3	-	3	40	60	-	-	-	100
RAPC510P	PCC	Embedded System in Robotics Lab	-	2	-	2	-	1	1	-	-	-	-	25	25
RAPE501	PEC	Program Elective Course - I *	3	-	-	3	3	-	3	40	60	-	-	-	100
RAPE501P	PEC	Program Elective Course - I * Lab	-	2	-	2	-	1	1	-	-	-	-	25	25
RAMD503	MDM	Project Management System - II	-	2	-	2	-	1	1	-	-	25	-	-	25
ALOE503	OE	Open Elective - III #	2	-	-	2	2	-	2	-	-	50	-	50	100
RAAE502	AEC	Robot Operating System	-	2	-	2	-	1	1	-	-	-	-	50	50
RAIN504	ELC - INT	Internship - IV	4 Weeks				-	2	2	-	-	25	-	-	25
Total			14	12	0	26	14	8	22	160	240	100	25	175	700

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* - Select any one course from the given Program Elective Courses		
Course Code	Course Type	Program Elective-I
RAPE501A	PEC	Flexible Manufacturing System
RAPE501B		Artificial Intelligence for Robotics
RAPE501C		Fundamentals of Numerical Methods for Robotics

# - Select any one course from the given Open Elective Courses		
Course Code	Course Type	Open Elective - III
ALOE503A	OEC	Data Analytics
ALOE503B		Green Building
ALOE503C		Electric Mobility
ALOE503D		Introduction to Stock Market
ALOE503E		Patent Law for Engineers and Scientist



BoS Chairman




Director

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Third Year B. Tech. – Robotics & Automation: Semester - VI

Course Code	Course Type	Course Name	Teaching Scheme (Hrs./Week)							Evaluation Scheme					
			L	P	T	H	CR			CIE	ETE	TW	PR	OR	Total
							TH	PR/Tut	Total						
RAPC611	PCC	Industrial Automation	3	-	-	3	3	-	3	40	60	-	-	-	100
RAPC611P	PCC	Industrial Automation Lab	-	2	-	2	-	1	1	-	-	-	-	25	25
RAPC612	PCC	Robot Programming & Simulations	3	-	-	3	3	-	3	40	60	-	-	-	100
RAPC612P	PCC	Robot Programming & Simulations Lab	-	2	-	2	-	1	1	-	-	-	-	50	50
RAPE604	PEC	Program Elective Course - II *	3	-	-	3	3	-	3	40	60	-	-	-	100
RAPE604P	PEC	Program Elective Course - II * Lab	-	2	-	2	-	1	1	-	-	-	-	25	25
RAPE605	PEC	Program Elective Course - III *	2	-	-	2	2	-	2	40	60	-	-	-	100
RAPE605P	PEC	Program Elective Course - III * Lab	-	2	-	2	-	1	1	-	-	-	-	25	25
RAMD604	MDM	Robot Control Systems	3	-	-	3	3	-	3	40	60	-	-	-	100
RAMD604P	MDM	Robot Control Systems Lab	-	2	-	2	-	1	1	-	-	-	-	25	25
RAVS507	VSEC	Quality Management System - III	-	2	-	2	-	1	1	-	-	25	-	-	25
RAIN505	ELC - INT	Internship - V	4 Weeks					2	2			25	-	-	25
Total			14	12	0	26	14	8	22	200	300	50	-	150	700

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* - Select any one course from the given Program Elective Courses		
Course Code	Course Type	Program Elective-II
RAPE604A	PEC	Additive Manufacturing
RAPE604B		Machine Learning for Robotics
RAPE604C		Computational Techniques in Robotics

* - Select any one course from the given Program Elective Courses		
Course Code	Course Type	Program Elective-III
RAPE605A	PEC	Industrial Robotics and Material Handling Systems
RAPE605B		Robotics Internet of Things
RAPE605C		Mobile and Autonomous Robots



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SYLLABUS

SEMESTER - V

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Industrial Hydraulics and Pneumatics.							Code: RAPC508		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites:									
Physics, Chemistry, Engineering Mechanics, Basic of Fluid Mechanics.									
Course Objectives:									
1. To understand the fundamentals and applications of hydraulic and pneumatic fluid power systems. 2. To understand the construction, operation, performance, and selection of hydraulic pumps and reservoirs. 3. To apply the principles of hydraulic cylinders and motors for actuator operation and performance analysis. 4. To analyze the operation and characteristics of hydraulic control valves used in fluid power systems. 5. To design hydraulic and pneumatic circuits for different industrial applications. 6. To apply PLC and electro-hydraulic/pneumatic control principles for automation applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Understand fluid power principles and identify their applications in industrial automation and robotics.								
CO2	Explain the working, performance, and selection of hydraulic pumps and reservoir capacity.								
CO3	Apply hydraulic actuator principles to analyze cylinder and motor performance, loading, and operation.								
CO4	Analyze the construction, operation, and performance of directional, pressure, and flow control valves.								
CO5	Design hydraulic and pneumatic circuits for sequencing, speed control, pressure control, and regeneration.								
CO6	Apply ladder logic and electro-hydraulic/pneumatic control techniques to automate simple industrial applications.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Fluid Power Systems: Introduction to Hydraulics and Pneumatics, Fluid power system basics, Properties of hydraulic fluids, Pascal’s law and fluid power principles, energy losses in hydraulic systems, Industrial applications in robotics and automation.								06
2.	Hydraulic Pumps and Reservoir Design: Classification of Hydraulic Pumps, Pumping Theory of Positive Displacement Pumps. Construction and working of: Gear Pumps, Vane Pumps, Piston Pumps Fixed and Variable Displacement Pumps, Pump Performance Characteristics, Pump Selection Factors, Numerical Problems on Hydraulic Pumps, Design of Hydraulic Reservoir Capacity.								06

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3.	Hydraulic Actuators (Cylinders and Motors): Classification of Hydraulic Cylinders and Hydraulic Motors, Linear Hydraulic Actuators (Hydraulic Cylinders): Single-Acting Cylinder, Double-Acting Cylinder. Mechanics of Hydraulic Cylinder Loading, Mounting Arrangements, Cushioning in Hydraulic Cylinders, Numerical Problems on Hydraulic, Cylinders. Hydraulic Motor Theory: Theoretical Torque, Power and Flow, Rate, Performance Characteristics, Numerical Problems on Hydraulic Motors, Symbolic Representation of Hydraulic Actuators (Cylinders and Motors)	07
4.	Hydraulic Valve Systems and Control: Classification of control valves, Directional Control Valves- Symbolic representation, and constructional features of poppet, sliding spool, solenoid and pilot operated DCV, shuttle valve, check valves, Pressure control valves - types, direct operated types and pilot operated types. Flow Control Valves - compensated and non-compensated FCV, needle valve, pressure compensated, pressure and temperature compensated FCV.	06
5.	Hydraulic and Pneumatic Circuits Designs: Basic hydraulic circuits, Regenerative circuits, Sequencing circuits, Pneumatic logic circuits, Speed control circuits, Pressure control circuits, Circuit symbols and diagrams	07
6.	Electro-Hydraulics and Electro-Pneumatic Systems: PLC programming using ladder logic for automation and robotics applications, PLC-based electro-hydraulic systems, Electro-Pneumatic Control: Principles - signal input and out-put, pilot assisted solenoid control of directional control valves, Use of relay and contactors. Control circuitry for simple applications	07
TOTAL		39
Text Books:		
1. Industrial Hydraulics and Pneumatics — Industrial Hydraulics and Pneumatics by Pippenger and Hicks, Publisher: McGraw Hill 2. Pneumatic Systems: Principles and Maintenance — Pneumatic Systems: Principles and Maintenance by S. R. Majumdar, Publisher: Tata McGraw Hill 3. Oil Hydraulic Systems — Oil Hydraulic Systems by S. R. Majumdar, Publisher: McGraw Hill 4. Hydraulic and Pneumatic Controls — Hydraulic and Pneumatic Controls by R. Srinivasan, Publisher: Vijay Nicolpilot-assistede Imprints		
Reference Books:		
1. Fluid Power Circuits and Controls — Fluid Power Circuits and Controls by John S. Cundiff 2. Hydraulic Control Systems — Hydraulic Control Systems by Herbert E. Merritt 3. Hydraulic and Pneumatic Systems — Hydraulic and Pneumatic Systems by R. K. Rajput 4. Electro Pneumatics and Hydraulics — Electro Pneumatics and Hydraulics by Xavier 5. Industrial Automation and Process Control — Industrial Automation and Process Control by Jon Stenerson. 7. A. Esposito, Fluid Power with Applications, 7th ed. New Delhi: Pearson India Education, 2013.		

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E-Resources:

1. NPTEL – Fluid Power Systems
<https://chatgpt.com/c/6a169481-2b60-83e8-a025-75137099f76e>
2. Alison – Pneumatics and Hydraulics Courses
https://alison.com/?utm_source=chatgpt.com

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Industrial Hydraulics and Pneumatics Lab							Code: RAPC508P		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	-	25	25
Prerequisites:									
Physics, Chemistry, Engineering Mechanics, Basic of Fluid Mechanics.									
Course Objectives:									
1. To understand cylinder actuation and control circuits.									
2. To design sequencing, synchronization, and regenerative circuits.									
3. To apply different cylinder speed-control methods.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Develop single- and double-acting cylinder circuits.								
CO2	Design reciprocation, sequencing, and synchronization circuits.								
CO3	Implement meter-in and meter-out speed control.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
Any FOUR From Part A and Any FOUR From Part B									
Part A (Hydraulic)									
1.	Experiment on actuation of single acting cylinder.							02	
2.	Experiment on actuation of double acting cylinder.							02	
3.	Experiment on reciprocating of double acting cylinder.							02	
4.	Experiment on regenerative Circuit.							02	
5.	Experiment on cylinder sequencing circuit.							02	
6.	Experiment on cylinder Synchronization in series and parallel.							04	
7.	Performance on meter in speed control.							04	
8.	Performance on meter out speed control.							04	
Part B (Pneumatic)									
1.	Experiment on direct actuation of single acting cylinder using 3/2 DCV.							02	
2.	Experiment on direct actuation of double acting cylinder using 5/2 DCV.							02	
3.	Experiment on direct actuation of single acting cylinder using 5/3 DCV.							02	
4.	Experiment on reciprocating double acting cylinder using 5/3 DCV.							02	
5.	Experiment on two handed safety circuit (AND logic).							02	
6.	Experiment on OR Logic circuit.							02	
7.	Experiment on cylinder Synchronization in series and parallel.							04	
8.	Performance on meter in speed control.							04	
9.	Performance on meter out speed control.							04	
10.	Performance on regenerative Circuit.							04	
TOTAL								26	

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Reference Books:
1. Hydraulic and Pneumatic Systems — Hydraulic and Pneumatic Systems by R. K. Rajput 2. Industrial Automation and Process Control — Industrial Automation and Process Control by Jon Stenerson. 3. Hydraulics and Pneumatics Controls — Hydraulics and Pneumatics Controls by Andrew Parr
E-Resources:
1. Bosch Rexroth Hydraulics Training https://www.boschrexroth.com/en/dc/?utm_source=chatgpt.com

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Design of Robot Elements							Code: RAPC509		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites:									
Engineering Mathematics, Materials, Engineering Mechanics, Manufacturing Processes, Robotics.									
Course Objectives:									
1. Understand robot mechanical design principles. 2. Study robot structures and configurations. 3. Design robotic transmission systems. 4. Select suitable actuators and mechanical elements. 5. Develop industry-oriented robotic products.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the fundamentals of robot mechanical design, robot configurations, material selection, load analysis, and design standards.								
CO2	Design couplings and shafts for robotic power transmission systems.								
CO3	Select suitable bearings for robotic applications based on load and operating conditions.								
CO4	Design gear drives for robotic motion transmission systems.								
CO5	Design belt and chain drives for robotic power transmission applications.								
CO6	Develop robotic grippers and end-effectors for industrial robotic applications.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Fundamentals of Robot Mechanical Design: Introduction to robot elements, Robot structure & configuration, Degrees of freedom, Load analysis, Material selection, Factor of safety, Design process in robotics, Design standards.							06	
2.	Design of Couplings: Design considerations, Classification, Design of Rigid, Muff coupling, Flange coupling and Flexible bushed pin coupling. Design of Shafts: Shafts: Design considerations in Transmission shafts with spur gear and pulley, splined Shafts, Shaft design on strength basis, Shaft design on torsional rigidity basis, and ASME code for shaft design.							07	
3.	Bearings: Types and application, Sliding contact bearings, Reynold's equation (2D), Petroff's equations, Sommerfeld number, Parameters of bearing design. Rolling contact bearings - Static and dynamic load capacity, equivalent bearing load, selection of bearing from manufacturers catalogue, design for variable load and speeds, selection of deep groove ball bearings, lubrication and mounting of bearing.							07	

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4.	Gear Drives: Design considerations of gears, material selections, terminologies used in gears, types of gears, Form of tooth in gears, types of gear tooth failures, Law of Gearing, Design of Spur gears, Bevel and Helical gears.	06
5.	Belt and Chain Drives: Introduction and types of belt drives. Flat belt: Design of Open flat belt and crossed flat belt. V-belt: Design of V-belt. Timer Belt: Design of Timer Belt. Chain Drive: Design of simple chain drive.	06
6.	Design of Grippers: Classification, design consideration, Mechanical Grippers: designing of Linkage Based, Gear Based, Cam type, Screw based, and O-ring grippers; grippers using pneumatic, hydraulic and electrical motor for transmission and its designing; Vacuum Grippers and its designing.	07
TOTAL		39
Text Books:		
1. H. Asada and Jean-Jacques E. Slotine, Robot Analysis and Design, Wiley India / John Wiley & Sons. 2. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani and Giuseppe Oriolo, Robotics: Modelling, Planning and Control, Springer. 3. V. B. Bhandari, Design of Machine Elements, McGraw-Hill Education (India). 4. John J. Craig, Introduction to Robotics: Mechanics and Control, Pearson Education. 5. Mikell P. Groover, Industrial Robotics: Technology, Programming and Applications, McGraw-Hill Education.		
Reference Books:		
1. Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, Robotic Engineering: An Integrated Approach, Prentice Hall. 2. Robert C. Juvinall and Kurt M. Marshek, Fundamentals of Machine Component Design, Wiley.		
E-Resources:		
1. NPTEL Robotics and Control Course (IIT Guwahati): https://nptel.ac.in/courses/112103280 2. MIT Open Course Ware Introduction to Robotics Portal: https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/ 3. ISO 8373:2021 Robotics Vocabulary Database: https://www.iso.org/standard/75631.html 4. NPTEL Design of Machine Elements II (IIT Kharagpur): https://nptel.ac.in/courses/112105125 5. SKF Rolling Contact Bearing Life & Selection Calculator: https://www.skf.com/com/support/engineering-tools/skf-bearing-calculator 6. Directory of Open Access Books (DOAB) Engineering Repository: https://www.doabooks.org		

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Design of Robot Elements Lab							Code: RAPC509P		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Engineering Mathematics, Materials, Engineering Mechanics, Manufacturing Processes, Engineering Drawing, Robot Fundamentals									
Course Objectives:									
1. To comprehend fundamental mechanical properties and operational principles of various machine components in robotic system design.									
2. To demonstrate systematic design procedures for evaluating power transmission components like shafts, couplings, and drive systems.									
3. To design advanced gear mechanisms, mechanical grippers, and actuated robotic end effectors for practical industrial applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Comprehend core mechanical properties, sliding journal bearings, and fundamental concepts that govern modern robotic component design.								
CO2	Demonstrate structured analytical procedures for evaluating mechanical shafts, couplings, and flexible belt or chain drive systems.								
CO3	Design custom gear trains, mechanical gripper models, and actuated end effectors for specific industrial automation tasks.								
Course Contents:									
Exp. No	Description							Duration (Hrs.)	
Any EIGHT form the following.									
1.	Explain fundamentals of mechanical properties used in Robot design.							02	
2.	Give step by step procedure for Design of Couplings and Shafts.							04	
3.	Explain in detail Design procedure of Sliding and Journal Bearings.							02	
4.	Explain Design of Gears.							02	
5.	Analysis, and Failure Assessment of Gear Drives							02	
6.	Design of Belt and Chain Drives							04	
7.	Comparative Analysis of Flexible Power Transmission Systems							02	
8.	Mechanical Gripper Modelling							04	
9.	Actuated Gripper Modelling							04	
Total							26		
Reference Books:									
1. Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, Robotic Engineering: An Integrated Approach, Prentice Hall.									
2. Robert C. Juvinall and Kurt M. Marshek, Fundamentals of Machine Component Design, Wiley.									
E-Learning:									
1. NPTEL Robotics and Control Course (IIT Guwahati): https://nptel.ac.in/courses/112103280									

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Embedded System in Robotics							Code: RAPC510		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Microprocessors & Microcontrollers, Digital Electronics, C Programming									
Course Objectives:									
1. Understand the fundamental concepts of embedded systems. 2. Explain the architecture, internal organization of ARM-based microcontrollers, related to ARM7 (LPC2148), ARM Cortex-M (STM32) processors. 3. Understand to program LPC2148 microcontrollers in embedded C, interface on-chip peripherals such as GPIO, timers, ADC, DAC, UART, SPI, and I2C. 4. Familiarize students with modern embedded development platforms, tools, libraries used for STM32 microcontrollers, including STM32CubeIDE, HAL drivers. 5. Develop the ability to design, implement, and debug embedded applications using interrupts, timers, communication protocols, and real-time constraints. 6. Give exposure to real-time operating system concepts, advanced embedded applications, preparing students for industry-oriented embedded system design, higher studies.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain embedded system architecture, different methodologies.								
CO2	Demonstrate real-time embedded applications using ARM7.								
CO3	Demonstrate LPC2148 for peripheral interfacing.								
CO4	Develop STM32 using HAL/LL libraries.								
CO5	Analyze different sensors, communication protocols, displays.								
CO6	Develop industry-oriented embedded applications.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Introduction to Embedded Systems Embedded system (ES) definition, Applications of Embedded Systems, Characteristics/ Design metrics of Embedded systems, Classification of Embedded system, Components of an Embedded system, Embedded system Design flow-Issues in Hardware-Software design and co-design, testing of embedded systems							07	
2.	ARM Processor Fundamentals ARM Architecture Details: Comparison of RISC and CISC processor, RISC architecture design philosophy, ARM Design Philosophy, Embedded System Hardware, Embedded System Software, ARM data flow model, Register banks, CPSR and SPSR, Pipelining, Exceptions, Interrupts & Vector Table, Core Extensions, Architecture Revisions							07	

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3.	LPC 2148 Microcontroller: Features, Block Diagram and Description, System Control Block, Memory Map, System Control Block (PLL and VPB divider), Pin Connect Block, GPIO, Timer Block for Delay Generation, LPC 2148 Interfacing with LED, Switches, Relay, Interfacing LCD and keypad, Timer/Counter, UART, ADC module.	06
4.	Introduction to ARM CORTEX M4Based Microcontroller: Introduction to ARM CORTEX series: CORTEX A, R, M processors, Firmware development using CMSIS Standard. Introduction to ARM CORTEX M4 microprocessor core, programmer model, Processor Modes, Memory Map, and Introduction Arm Cortex-M cores, STM32F4xx Architecture, ARM STM Bus Architecture, STM32F4xx Clock Interrupts and Exceptions.	06
5.	Real World Interfacing with Cortex M4 Based Microcontroller: GPIO Programming, Interfacing seven segment LED, LDR and MQ3 sensor with STM32F4xx, STM32F4xx: Counters and Timers: Timer and Delay Generation, UART Programming, on chip ADC and Onchip DAC for waveform generation.	07
6.	Communication Protocols: UART, USART, I2C, SPI, USB, Ethernet, CAN, ZIGBEE, Bluetooth, RS232, RS485 protocol, Features and comparisons of various protocols.	06
TOTAL		39

Text Books:

1. The Insider's Guide To The Philips ARM7-Based Microcontrollers (LPC2000 family) — Hitex / ARM-based
2. Embedded System Design: A Unified Hardware/Software Introduction Frank Vahid and Tony Givargis, John Wiley & Sons; ISBN: 0471386782. Copyright (c) 2002.
3. Raj Kamal – Embedded Systems: Architecture, Programming and Design
4. ARM Controller: ARM Fundamentals, LPC2148 CPU and Peripherals - A. P. Godse Joseph Yiu – The Definitive Guide to ARM Cortex-M3/M4

Reference Books:

1. Steve Furber – ARM System-on-Chip Architecture
2. Mastering STM32 (2nd Edition) — Carmine Noviello
3. Embedded Systems: Real-Time Interfacing to Arm Cortex-M Microcontrollers-Jonathan W. Valvano, Create Space Independent Publishing Platform

E-Resources:

1. Embedded Systems – Lecture Playlist & Course Content (IIT Delhi – NPTEL)
https://www.youtube.com/results?search_query=NPTEL+Embedded+Systems+IIT+Delhi
(Covers introduction, architecture, interfaces & real-time concepts)
2. NPTEL Embedded System Design with ARM (IIT Kharagpur)
https://www.youtube.com/results?search_query=NPTEL+Embedded+System+Design+with+ARM
(ARM microcontroller basics, architecture, interfacing & hands-on demos)
3. NPTEL Prep – Embedded System Design with ARM (Structured Video Lectures)
<https://www.nptelprep.in/courses/106105193/videos>

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Embedded System in Robotics Lab							Code: RAPC510P		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites: Microprocessors & Microcontrollers, Digital Electronics, C Programming									
Course Objectives:									
1. Understand ARM7, LPC2148, and STM32 architectures and peripherals.									
2. Develop embedded programs using Assembly, Embedded C, and HAL drivers.									
3. Implement and test GPIO, PWM, ADC, UART, LED, and stepper motor applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Develop and simulate ARM7 programs for arithmetic, shifting, addressing modes, and sorting.								
CO2	Implement LPC2148 and STM32 GPIO, timer, PWM, and ADC applications.								
CO3	Interface embedded peripherals and implement UART communication using STM32 HAL.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
LPC2148 Experiments: Any FIVE from the Following.									
1.	Develop Program for addition and subtraction of 32 bit numbers on ARM7 and simulate using keil software							02	
2.	Develop Program for barrel shifter and simulate using keil software							02	
3.	Develop program for different addressing modes in ARM7 and simulate using keil software							02	
4.	Develop Program for arranging 10 bytes in ascending and descending order and simulate using keil software							02	
5.	Develop embedded C Program for square wave generation on ARM7 and simulate using keil software							02	
6.	Develop embedded C program for LED interfacing to LPC2148 to generate different patterns and implement on Hardware kit							02	
7.	Develop embedded C Program for stepper motor interface to LPC 2148 and implement on hardware kit							04	
STM32 Experiments: Any THREE from the Following.									
1.	GPIO using HAL: To configure and control STM32 GPIO pins using HAL drivers.							02	
2.	Timer & PWM: To generate PWM signals using STM32 timers for control applications.							02	
3.	ADC with DMA: To acquire analog sensor data using STM32 ADC with DMA for efficient data transfer.							02	
4.	UART Communication: To implement serial communication on STM32 using HAL-based UART drivers							04	
TOTAL								26	

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Text Books:

1. The Insider's Guide To The Philips ARM7-Based Microcontrollers (LPC2000 family) — Hitex / ARM-based.
2. Embedded System Design: A Unified Hardware/Software Introduction Frank Vahid and Tony Givargis, John Wiley & Sons; ISBN: 0471386782. Copyright (c) 2002.
3. Raj Kamal – Embedded Systems: Architecture, Programming and Design.
4. ARM Controller: ARM Fundamentals, LPC2148 CPU and Peripherals - A. P. Godse Joseph Yiu – The Definitive Guide to ARM Cortex-M3/M4.

Reference Books:

1. Steve Furber – ARM System-on-Chip Architecture.
2. Mastering STM32 (2nd Edition) — Carmine Noviello.
3. Embedded Systems: Real-Time Interfacing to Arm Cortex-M Microcontrollers-Jonathan W. Valvano, Create Space Independent Publishing Platform.

E-Resources:

1. Embedded Systems – Lecture Playlist & Course Content (IIT Delhi – NPTEL)
https://www.youtube.com/results?search_query=NPTEL+Embedded+Systems+IIT+Delhi
(Covers introduction, architecture, interfaces & real-time concepts)
2. NPTEL Embedded System Design with ARM (IIT Kharagpur)
https://www.youtube.com/results?search_query=NPTEL+Embedded+System+Design+with+ARM
3. NPTEL Prep – Embedded System Design with ARM (Structured Video Lectures)
<https://www.nptelprep.in/courses/106105193/videos>

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PROGRAM ELECTIVE - I
(Select any one course from the given Open
Elective Courses)

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Flexible Manufacturing Systems							Code: RAPE501A		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites:									
Manufacturing Processes, Elements of Electrical and Electronics Engineering, Engineering Graphics.									
Course Objectives:									
1. Understand the fundamentals of automation and flexible manufacturing systems. 2. Learn material handling, storage, and inspection systems in manufacturing. 3. Develop CNC programming skills for automated manufacturing operations. 4. Understand Computer Integrated Manufacturing and Industry 4.0 concepts. 5. Analyze and design flexible manufacturing systems effectively. 6. Explore industrial applications and emerging trends in manufacturing automation.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Understand automation systems, flexible manufacturing concepts, and their industrial applications.								
CO2	Explain the operation of material handling and automated inspection systems used in manufacturing.								
CO3	Demonstrate basic CNC part programs and explain the operation of CNC systems.								
CO4	Explain the integration of manufacturing systems through CIM and Industry 4.0 technologies.								
CO5	Analyze flexible manufacturing systems using material handling and production planning techniques.								
CO6	Apply flexible manufacturing concepts to solve manufacturing and automation problems in industrial applications.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Introduction to Automation and Flexible Manufacturing: Evolution of Manufacturing Systems, Types of Automation: Fixed Automation Programmable Automation, Flexible Automation, Need of Flexible Manufacturing in Industry 4.0, Components of FMS, Types of FMS layouts, Advantages and limitations of FMS.							06	
2.	Material Handling and Automated Inspection Systems: Automated Material Handling Systems, Conveyor systems, Automated Guided Vehicles (AGVs), Automated Storage and Retrieval Systems (ASRS), Barcode and RFID systems, Computer Vision in manufacturing, Coordinate Measuring Machines (CMM), Automated inspection concepts.							06	

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3.	CNC Technology and Part Programming: CNC Technology and Part Programming: Introduction to NC, CNC & DNC machines, Construction and working of CNC machines, CNC machine axes and coordinate systems, Open-loop and closed-loop control, Manual part programming using: G Codes, M Codes, CNC turning and milling examples.	07
4.	Computer Integrated Manufacturing (CIM) and Industry 4.0: Introduction to CIM, CIM architecture, CAD/CAM/CAPP integration, Database systems in manufacturing, IoT in manufacturing, Cloud manufacturing, Digital Twin concept, Smart Factory and Industry 4.0 overview, Cyber Physical Systems (CPS).	06
5.	Design of Flexible Manufacturing Systems: Design considerations for conveyors, AGVs, ASRS, Pallet systems, Workpiece flow analysis, CPM, PERT, Markov chain analysis for production systems with discrete time and continuous time analysis.	07
6.	Applications and Case Studies in Flexible Manufacturing: Cellular Manufacturing and Group Technology, Flexible Manufacturing Cells, Lean Manufacturing basics, Agile Manufacturing, Additive Manufacturing integration with FMS, Case studies: Automotive production lines, Electronics manufacturing, Medical device manufacturing.	07
TOTAL		39

Text Books:

1. Groover, M. P., & Zimmers, E. W. Jr. CAD/CAM: Computer-Aided Design and Manufacturing. 1st Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 1984. ISBN: 978-0131069089.
2. Koren, Yoram. Robotics for Engineers. McGraw-Hill Book Company, New York, 1985. ISBN: 978-0070353508.
3. Vajpayee, S. Kant. Principles of Computer Integrated Manufacturing. Prentice Hall of India (PHI Learning Pvt. Ltd.), New Delhi, 1995. ISBN: 978-8120310334.
4. Viswanadham, N., & Narahari, Y. Performance Modeling of Automated Manufacturing Systems. Prentice Hall of India (PHI Learning Pvt. Ltd.), New Delhi, 1992. ISBN: 978-8120308362.

Reference Books:

1. Groover, M. P. Automation, Production Systems, and Computer-Integrated Manufacturing. 4th Edition, Pearson Education, 2015. ISBN: 978-0133499617.
2. Kalpakjian, S., & Schmid, S. R. Manufacturing Engineering and Technology. 8th Edition, Pearson Education, 2020. ISBN: 978-0135228604.
3. Mikell P. Groover. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems. 7th Edition, Wiley, 2020. ISBN: 978-1119722019.
4. Chang, T. C., Wysk, R. A., & Wang, H. P. Computer-Aided Manufacturing. 3rd Edition, Pearson Education, 2006. ISBN: 978-0131429197.
5. P. Radhakrishnan, S. Subramanyan, & V. Raju. CAD/CAM/CIM. 3rd Edition, New Age International Publishers, 2008. ISBN: 978-8122424893.
5. Mikell P. Groover. Industrial Robotics: Technology, Programming, and Applications. McGraw-Hill Education, 1986. ISBN: 978-0070249894.

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E-Resources:

1. Coursera – Lean Manufacturing & Robotics for Flexible Systems.
<https://www.coursera.org/learn/lean-manufacturing-robotics-for-flexible-systems>
2. NPTEL/IIT Kharagpur – Industrial Automation and Control.
<https://www.getyoureducation.net/course/industrial-automation-and-control>
3. NPTEL/IIT Guwahati – Automation in Manufacturing.
<https://www.getyoureducation.net/course/automation-in-manufacturing-1>
4. NPTEL/IIT Kharagpur – Automation in Production Systems and Management
<https://www.getyoureducation.net/course/automation-in-production-systems-and-management>

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Flexible Manufacturing Systems Lab							Code: RAPE501AP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	-	25	25
Prerequisites:									
Engineering Graphics, Manufacturing Processes.									
Course Objectives:									
1. To understand the fundamentals of FMS and CIM systems.									
2. To develop skills in CNC, robot, and material-handling operations.									
3. To understand FMS planning, scheduling, and simulation.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain major components of FMS.								
CO2	Perform basic CNC, robot, and automated material-handling operations.								
CO3	Analyze and simulate FMS for efficient production planning.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
Any EIGHT form the following.									
1.	Study of Flexible Manufacturing System (FMS)							02	
2.	Part Programming for CNC Turning							04	
3.	Part Programming for CNC Milling							04	
4.	Robot Programming for Material Handling							02	
5.	Robot-Based Machine Loading and Unloading							02	
6.	Automatic Part Identification and Sorting							02	
7.	Conveyor-Based Material Handling							02	
8.	Automated Storage and Retrieval System (AS/RS)							02	
9.	Computer Integrated Manufacturing (CIM)							02	
10.	FMS Scheduling and Production Planning							02	
11.	AGV-Based Material Transportation							02	
12.	Simulation of a Flexible Manufacturing System							02	
TOTAL							26		
Reference Books:									
1. Groover, M. P. Automation, Production Systems, and Computer-Integrated Manufacturing. 4th Edition, Pearson Education, 2015. ISBN: 978-0133499617.									
2. Kalpakjian, S., & Schmid, S. R. Manufacturing Engineering and Technology. 8th Edition, Pearson Education, 2020. ISBN: 978-0135228604.									
3. P. Radhakrishnan, S. Subramanyan, & V. Raju. CAD/CAM/CIM. 3rd Edition, New Age International Publishers, 2008. ISBN: 978-8122424893.									
E-Resources:									
Virtual Lab on Manufacturing Processes: https://vlabs.iitkgp.ac.in/vmp/index.html#									

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Artificial Intelligence for Robotics							Code: RAPE501B		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites:									
Engineering Mathematics, Engineering Mechanics, Basic Programming Languages									
Course Objectives:									
1. Introduce state-space models and evaluate core agent architectures for physical robotic environments. 2. Implement uninformed, informed (A*), and adversarial search techniques for autonomous navigation. 3. Familiarize NLP and Large Language Models (LLMs) to automate robotic command parsing and code generation. 4. Demonstrate sensor fusion and trajectory optimization techniques while integrating ethical safety frameworks. 5. Optimize real-time scheduling, tool tracking, and automated routing within flexible manufacturing layouts. 6. Provide a clear taxonomy of machine learning types, datasets, and feature engineering for manufacturing.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Understand physical robotic tasks and environmental constraints within mathematical state spaces.								
CO2	Interpret optimal search paths and adversarial choice strategies for dynamic mobile robot navigation.								
CO3	Deploy Generative AI prompt pipelines to translate natural language into executable robot scripts.								
CO4	Examine multi-sensor data profiles to ensure safe, collision-free autonomous navigation.								
CO5	Validate optimized routing networks and real-time schedules for automated storage assets.								
CO6	Synthesize raw robotic telemetry and industrial datasets into engineered feature sets for machine learning.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Introduction to AI and Intelligent Agents: Introduction to AI, Core concepts, goals of AI in robotics & automation, history, and state-of-the-art applications in robotics. Environments & Problem Solving, Types of robotic environments, formulating problems as state spaces, discrete vs. continuous state spaces, and initial concept of search spaces for physical manipulators.							07	
2.	Uninformed, Informed, and Adversarial Search Techniques: Breadth-First Search (BFS), Depth-First Search (DFS), and Dijkstra's algorithm. Informed search: Greedy Best-First and A* algorithm. Game theory foundations, optimal choices in collaborative/adversarial work cells, Minimax algorithm, and Alpha-Beta pruning.							07	

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3.	NLP & Generative AI in Robotics: Foundations of Natural Language Processing in Human-Robot Interaction (HRI). Tokenization, word embedding, and intent parsing for robotic commands. Introduction to Large Language Models (LLMs) Prompt engineering for task decomposition, semantic planning, and language-to-code generation (ROS2 actions).	07
4.	Robotic Intelligence & Autonomous Navigation: Robot Perception and Sensor Fusion, AI in Mobile Robots and Obstacle Avoidance, Path Planning and Trajectory Optimization, Human-Robot Interaction, AI Ethics and Explainable AI, Safety Framework	07
5.	Smart Automation: Flexible Manufacturing Systems (FMS) and Real-Time Scheduling, Smart Tool Tracking, Automated Storage and Retrieval Systems (AS/RS) Route Planning	05
6.	Introduction to Machine Learning: Why Machine Learning, AI vs ML vs DL, Types of Learning, Dataset Concepts, Features and Labels, Data Collection, Future of AI, Data Stack	06
TOTAL		39
Text Books:		
1. Automation, Production Systems, and Computer-Integrated Manufacturing (4th/5 th Edition) – Mikell 2. P. Groover. Pearson Education. ISBN: 978-9332549814. 3. Introduction to Robotics: Mechanics and Control (4th Edition) – John J. Craig. Pearson Education. ISBN: 978-0133489798. 4. Machine Vision Algorithms and Applications (2nd Edition) – Carsten Steger, Markus Ulrich, and Christian Wiedemann. Wiley-VCH. ISBN: 978-3-527-41365-2. 5. Artificial Intelligence: A Modern Approach – Stuart Russell and Peter Norvig. Pearson Education. 6. Evolutionary Computations for Manufacturing – P. J. Pawar. Studium Press. ISBN: 978-93-85046-52-0.		
Reference Books:		
1. Robotics: Control, Sensing, Vision, and Intelligence – K.S. Fu, R.C. Gonzalez, and C.S.G. Lee. Tata McGraw-Hill. ISBN: 978-0070226272. 2. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms – Nikolaus Correll, Bradley Hayes, and Alcherio Martinoli. MIT Press. ISBN: 978-0262034722. 3. Modern Robotics: Mechanics, Planning, and Control – Kevin M. Lynch and Frank C. Park. Cambridge University Press. ISBN: 978-1107156302. 4. Robotics and Automation Handbook – Thomas R. Kurfess. CRC Press. ISBN: 978-0849318047. 5. Artificial Intelligence – S. Bhattacharya. Laxmi Publications, Ltd. ISBN: 978-8131804896. 6. Artificial Intelligence – Rajiv Chopra. S. Chand Publishing. ISBN: 978-8121939485. 7. Machine Vision – Ramesh Jain, Rangachar Kasturi, and Brian G. Schunck. McGraw-Hill, Inc. ISBN: 0-07-032018-7.		

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E-Resources:

1. NPTEL: Introduction to Robotics :Offered by IIT Kanpur
https://onlinecourses.nptel.ac.in/noc24_me88/preview
2. Coursera: Robotics Specialization: Offered by the University of Pennsylvania
<https://www.coursera.org/specializations/robotics>
3. MIT OpenCourseWare: Introduction to Robotics Course No. 2.12 - Department of Mechanical Engineering
<https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/>

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Artificial Intelligence for Robotics Lab							Code: RAPE501BP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Engineering Mathematics, Engineering Mechanics, Basic Programming Languages.									
Course Objectives:									
1. Implement state-space modelling, A* search, and collision-free path planning. 2. Apply Minimax, NLP, LLM prompting, and APF for robotic decision-making. 3. Develop AGV routing and smart automation pipelines using Python and optimization algorithms.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Understand search, planning, NLP, and optimization techniques for robotics.								
CO2	Develop Python programs for path planning, command parsing, and trajectory generation.								
CO3	Implement intelligent AGV and robotic automation solutions using AI algorithms.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Formulation of an Environment State-Space Grid and Wall Connections using NumPy and Matplotlib.							02	
2.	Implementation of the A* (A-Star) Search Algorithm with Manhattan and Euclidean Distance Heuristics for Route Finding.							02	
3.	Implementation of the Minimax Algorithm with Alpha-Beta Pruning to Handle Collaborative Work-Cell Schedules.							02	
4.	Application of Text Tokenization, Vocabulary Word Embeddings, and User Command Parsing for Human-Robot Interfaces.							02	
5.	Execution of Large Language Model (LLM) Prompt Engineering for High-Level Action Sequence Generation and Action Decompositions.							04	
6.	Implementation of Local Collision Avoidance and Trajectory Modification using Artificial Potential Fields (APF).							04	
7.	Design of Dynamic AGV Routing and Traveling Salesperson Fleet Optimization using Genetic Algorithm Loops.							04	
8.	(Mini-Pipeline Project): End-to-End Smart Automation Pipeline : Develop a unified Python pipeline within any suitable software that takes a natural language instruction (e.g., "Move the component to coordinates 4,8"), parses the command using basic text filtering, generates a coordinate vector, runs the A* search algorithm to map a collision-free path to that target location, and plots the real-time movement trajectory.							08	
TOTAL							26		

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Text Books:

1. Automation, Production Systems, and Computer-Integrated Manufacturing (4th/5th Edition) – Mikell
2. P. Groover. Pearson Education. ISBN: 978-9332549814.
3. Introduction to Robotics: Mechanics and Control (4th Edition) – John J. Craig. Pearson Education. ISBN: 978-0133489798.
4. Machine Vision Algorithms and Applications (2nd Edition) – Carsten Steger, Markus Ulrich, and Christian Wiedemann. Wiley-VCH. ISBN: 978-3-527-41365-2.
5. Artificial Intelligence: A Modern Approach – Stuart Russell and Peter Norvig. Pearson Education.
6. Evolutionary Computations for Manufacturing – P. J. Pawar. Studium Press. ISBN: 978-93-85046-52-0.

Reference Books:

1. Robotics: Control, Sensing, Vision, and Intelligence – K.S. Fu, R.C. Gonzalez, and C.S.G. Lee. Tata McGraw-Hill. ISBN: 978-0070226272.
2. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms – Nikolaus Correll, Bradley Hayes, and Alcherio Martinoli. MIT Press. ISBN: 978-0262034722.
3. Modern Robotics: Mechanics, Planning, and Control – Kevin M. Lynch and Frank C. Park. Cambridge University Press. ISBN: 978-1107156302.
4. Robotics and Automation Handbook – Thomas R. Kurfess. CRC Press. ISBN: 978-0849318047.
5. Artificial Intelligence – S. Bhattacharya. Laxmi Publications, Ltd. ISBN: 978-8131804896.
6. Artificial Intelligence – Rajiv Chopra. S. Chand Publishing. ISBN: 978-8121939485.
7. Machine Vision – Ramesh Jain, Rangachar Kasturi, and Brian G. Schunck. McGraw-Hill, Inc. ISBN: 0-07-032018-7.

E-Resources:

1. NPTEL: Introduction to Robotics :Offered by IIT Kanpur
https://onlinecourses.nptel.ac.in/noc24_me88/preview
2. Coursera: Robotics Specialization: Offered by the University of Pennsylvania
<https://www.coursera.org/specializations/robotics>
3. MIT OpenCourseWare: Introduction to Robotics Course No. 2.12 - Department of Mechanical Engineering
<https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/>

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Fundamental of Numerical Methods for Robotics							Code: RAPE501C		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Engineering Mathematics									
Course Objectives:									
1.Develop the mathematical foundation required for numerical computation. 2.Understand numerical errors involved in engineering calculations. 3.Apply numerical techniques to solve algebraic equations. 4.Apply interpolation methods for function approximation. 5.Analyze numerical methods for differentiation, integration, and ordinary differential equations. 6.Develop the proficiency in finite difference methods for numerical solution of partial differential equations.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the concepts of numerical errors, convergence, and function approximation.								
CO2	Apply numerical methods to solve algebraic equations and systems of linear equations.								
CO3	Apply interpolation techniques to estimate unknown functional values.								
CO4	Analyze numerical differentiation, numerical integration, error estimation, extrema of Tabulated functions.								
CO5	Synthesize numerical solutions of ordinary differential equations using iterative methods.								
CO6	Evaluate finite difference solutions for elliptic and parabolic partial differential equations.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Approximations and Errors in Numerical Calculations: Introduction, Mathematical Preliminaries, Sequences of Real Numbers, Limits and Continuity, Differentiation, Integration, Taylor's Theorem, Orders of Convergence Accuracy of Numbers, Errors and their computations, Error in a series approximation, Error in the approximation of a function.							06	
2.	Solution of Algebraic and Transcendental Equations: Transformation of Equations, Iterative methods, Convergence, Bisection method, Secant method, Newton-Raphson method, Muller’s method. Solution of linear simultaneous equations: Direct methods of solution (Method of determinants, Matrix inversion method, Gauss elimination method							07	
3.	Interpolation: Introduction, Errors in Polynomial Interpolation, Forward and Backward interpolation- Newton’s and Gauss method. Central Difference interpolation formulae- Stirling’s formula, Bessel’s formula and Laplace-Everett’s formula. Choice of an Interpolation formula. Lagrange’s interpolation formula with unequal intervals, Iterative method for equal space distribution. Spline interpolation.							07	

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4.	Numerical Differentiation and Integration: Introduction, Derivatives using Newton's Forward, Backward and Stirling's Central Difference formulae, Errors in Numerical Differentiation, Maximum and Minimum values of a Tabulated function. Numerical Integration- Introduction, General Quadrature formulae-Trapezoidal rule, Simpson's $1/3^{\text{rd}}$ and $3/8^{\text{th}}$ rule, Errors in Quadrature formulae.	07
5.	Numerical Ordinary Differential Equations: Introduction, Solution by Taylor's Series, Picard's method, Euler's method, Euler's modified method, Runge's method, Runge-Kutta method, Predictor-Corrector methods, Convergence of a method.	06
6.	Numerical Partial Differential Equations: Introduction, Classification of second order equations, Finite-difference approximations to partial derivatives, Elliptic equations, Solutions of Laplace and Poisson's equation, Parabolic equations, Solution of one-dimensional heat equation.	06
TOTAL		39
Text Books:		
1. Chapra, S. C., and Canale, R. P., Numerical Methods for Engineers, McGraw-Hill Education, 8 th , Edition, 2020. 2. Sastry, S. S., Introductory Methods of Numerical Analysis, PHI Learning Private Limited, Eastern Economy Edition, Fifth Edition, 2023. 3. Grewal, B. S., Numerical Methods in Engineering and Science with Programs in C, C++ & MATLAB, Khanna Publishers, Eleventh Edition, 2017.		
Reference Books:		
1. Iyengar S. R. K., Numerical Methods New Age International (P) Limited, Publishers (2009). 2. James F. E., An Introduction to Numerical Methods and Analysis John Wiley & Sons (3rd Edition, 2021). 3. Rao, V. D., Numerical Methods, New Age International (P) Limited, Publishers (2010).		
E-Resources:		
1. Numerical Methods for Engineers (IIT Madras): https://nptel.ac.in/courses/127106019 2. Numerical Methods / Analysis (IIT Roorkee / SWAYAM): https://onlinecourses.nptel.ac.in/noc24_ma54/preview 3. Numerical Analysis (IIT Bombay): https://nptel.ac.in/courses/111101165 4. Stanford Online / Academic Portal: https://stanford.edu 5. Robot Academy: https://robotacademy.net.au 6. Virtual Labs (MHRD Initiative): https://vlab.co.in		

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Fundamentals of Numerical Methods Lab							Code: RAPE501CP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Engineering Mathematics									
Course Objectives:									
1. Students will compute various numerical methods to solve engineering and scientific computational problems accurately.									
2. Students will carefully analyze error propagation, convergence rates, and algorithmic performance in computational approximations.									
3. Students will evaluate the efficiency and accuracy of different iterative and direct computational schemes.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Learners successfully demonstrate practical implementation of root finding, interpolation, and differential equation solution techniques.								
CO2	Students thoroughly examine numerical stability and truncation errors inherent in various computational mathematical models.								
CO3	Learners critically validate overall method performance by comparing analytical solutions with numerical approximation results.								
List of Experiments:									
Exp. No	Description							Duration (Hrs.)	
All are compulsory									
1.	Computation of Truncation, Absolute, and Relative Errors in Taylor Series Approximation.							02	
2.	Root Finding of Non-Linear Equations using Bisection Method							02	
3.	Root Finding of Non-Linear Equations using Newton-Raphson Method							02	
4.	Solution of Simultaneous Linear Equations using Gauss Elimination Method							04	
5.	Data Interpolation using Lagrange’s Interpolation Formula							04	
6.	Numerical Integration using Simpson’s 1/3rd Rule							04	
7.	Solution of Initial Value Ordinary Differential Equations using 4th Order Runge-Kutta (RK4) Method							04	
8.	Solution of Elliptic Partial Differential Equations (2D Laplace Equation) using Finite Difference Method.							04	
Total							26		

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Text Books:

1. Chapra, S. C., and Canale, R. P., Numerical Methods for Engineers, McGraw-Hill Education, 8th Edition, 2020.
2. Sastry, S. S., Introductory Methods of Numerical Analysis, PHI Learning Private Limited, Eastern Economy Edition, Fifth Edition, 2023.
3. Grewal, B. S., Numerical Methods in Engineering and Science with Programs in C, C++ & MATLAB, Khanna Publishers, Eleventh Edition, 2017.

Reference Books:

1. Iyengar S. R. K., Numerical Methods New Age International (P) Limited, Publishers (2009).
2. James F. E., An Introduction to Numerical Methods and Analysis John Wiley & Sons (3rd Edition, 2021).

E-Learning:

1. Numerical Methods by Prof. Niket Kaisare (IIT Madras)
[NMS - Swayam NPTEL Preview](#)
2. NPTEL: Scientific Computing using MATLAB / Python
[NPTEL Digital Learning Platform \(DIGIMAT\)](#)
3. NPTEL: Numerical Analysis
[NPTEL Mathematics Courses via DIGIMAT](#)
4. MathWorks: Numerical Computing with MATLA
[MathWorks Learning Hub](#)

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Project Management System – II							Code: RAMD503		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	25	-	-	25
Prerequisites:									
Project Management System - I									
Course Objectives:									
1. To curate all project tasks to meet the needs of the company, consumers, and stakeholders.									
2. To schedule and divide different tasks and work among team members.									
3. To set the quality standard in a project.									
4. To use various PMS Software’s as per specific domain.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain various lifecycle models used in project management.								
CO2	Perform feasibility analysis and apply CPM & PERT Techniques.								
CO3	Understand project audit methodologies and scrum scheduling using Delphi Technique.								
CO4	Learn various project management software’s like JIRA, MSP, Teamwork.com, Trello etc.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Project Life cycle Management: Traditional project activity planning, agile project planning, coordination through integration management, project feasibility analysis, estimating project budget, project risk management, CPM, PERT, resource loading, resource leveling								08
2.	Project execution: Planning-monitoring-controlling cycle, earned value analysis, agile tool for tracking project, methods of project controlling, project audit, essentials of audit, evaluation, project closure, benefit realization, change management.								08
3.	Industry trends and software’s in project management: Enterprise project management, project success factor, standish factor of success, talent triangle, project governance, Change management, PMI’S code of conduct, software for project management, simulations software for project management.								10
TOTAL								26	
Text Books:									
1. Gary Richard Son, Brad Jackson, "Project Management Theory & Practice" CRC Press.									
2. John M. Nicholas, Herman Steyn, "Project Management for business engineering and technology", Elsevier.									
3. Arun Kanda, "Project Management: A Lifecycle Approach", PHI.									

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Reference Books:

1. “A Guide to the Project Management Body of Knowledge (PMBOK Guide)”, Project Management Institute.
2. B. B. Goel, “Project Management: Principles and Techniques”, Deep & Deep Publications Pvt. Ltd.

E-Resources:

1. Dr. Nimisha Singh, “Introduction to Project Management: Principles & Practices”, NPTEL Course - https://onlinecourses.swayam2.ac.in/imb25_mg167/preview
2. Prof. Raghu Nandan Sengupta, “Project Management”, NPTEL Course - https://onlinecourses.nptel.ac.in/noc25_mg78/preview
3. Project management for beginners by Ramesh Kumar
https://youtu.be/gnkjcRDQkw0?list=PLLy_2iUCG87CBuNhvti0h6W54ZmqrSDMJ

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OPEN ELECTIVE - III
(Select any one course from the given Open Elective Courses)

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Open Elective – III (Data Analytics)							Code: ALOE503A		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	-	-	50	50	-	100
Prerequisites:									
Basic knowledge of Mathematics and Statistics, Fundamentals of Computer Science									
Course Objectives:									
1. To introduce the types and applications of data analytics across domains. 2. To apply descriptive statistics and visualization techniques to summarize data. 3. To apply inferential statistics and hypothesis testing for decision-making. 4. To analyze relationships in data using correlation, regression, and ANOVA. 5. To build predictive models using classification and clustering techniques. 6. To familiarize students with prescriptive analytics and Big Data concepts.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the types of data analytics and their applications across domains.								
CO2	Apply descriptive statistics and visualization techniques to summarize data.								
CO3	Analyze data using inferential statistics and hypothesis testing methods.								
CO4	Apply correlation, regression, and ANOVA techniques for data-driven decisions.								
CO5	Design predictive models using classification and clustering approaches.								
CO6	Evaluate prescriptive analytics approaches and Big Data platforms for applications.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Data Analytics: Types of analytics — descriptive, diagnostic, predictive, and prescriptive; Analytics vs. reporting; Key applications across domains: business, healthcare, finance, and marketing; Overview of analytics tools landscape: Excel, Python, R, and Power BI (comparative overview); KPIs and metrics for decision-making.								04
2.	Descriptive Analytics: Frequency distributions, outliers; Measures of central tendency and dispersion; Interquartile range; Skewness and kurtosis; Normal distribution and z-scores; Data visualization principles: bar chart, histogram, box plot, scatter plot, and heat map.								05
3.	Inferential Statistics: Population vs. sample, random sampling; Sampling distribution, standard error; Hypothesis testing: null and alternate hypothesis, z-test, t-test; One-tailed and two-tailed tests; Confidence intervals and level of confidence; Type I and Type II errors.								05

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4.	Correlation, Regression & ANOVA: Correlation and scatter plots; Simple linear regression, least squares method; Multiple regression; Coefficient of determination (R^2); One-way and two-way ANOVA; Chi-square test of independence.	04
5.	Predictive Analytics: Introduction to predictive modeling; Classification techniques: logistic regression, decision trees; Clustering: k-means; Model evaluation: accuracy, confusion matrix; Time series analysis basics: moving averages, trend analysis.	04
6.	Prescriptive & Big Data Analytics: Prescriptive analytics: optimization and simulation for decision-making; Introduction to Big Data: the 5 V's, sources of big data; Overview of the Big Data ecosystem: Hadoop, Spark (conceptual only); Applications: business analytics, web analytics, and social media analytics.	04
TOTAL		26

Term Work:

Sr. No.	Title	Proposed Tutorial Activities
1.	Introduction to Data Analytics	Identify descriptive, diagnostic, predictive, and prescriptive analytics using real-world case studies. Compare Excel, Python, R, and Power BI for analytics tasks.
2.	Descriptive Statistics – I	Calculate mean, median, mode, range, variance, and standard deviation using a given dataset in Excel/Python.
3.	Descriptive Statistics – II	Detect outliers using IQR and visualize distributions using histograms and box plots.
4.	Data Visualization	Create bar charts, scatter plots, heat maps, and box plots. Interpret insights from visualizations.
5.	Sampling & Probability	Perform random sampling, calculate standard error, and differentiate between population and sample using datasets.
6.	Hypothesis Testing	Perform z-test and t-test for given scenarios and interpret Type I and Type II errors.
7.	Correlation & Regression	Calculate correlation coefficients, build simple linear regression models, and interpret R^2 values.
8.	ANOVA & Chi-Square	Perform one-way ANOVA and Chi-square tests using statistical software and interpret results.
9.	Predictive Analytics	Build basic classification models (Logistic Regression/Decision Tree) and perform K-Means clustering using Python.
10.	Model Evaluation	Evaluate predictive models using confusion matrix and accuracy metrics.
11.	Time Series Analytics	Apply moving averages and identify trends in time-series datasets.
12.	Big Data & Prescriptive Analytics	Explore Hadoop and Spark concepts through case studies and discuss optimization-based decision-making.

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Text Books:

1. Anil Maheshwari, "Data Analytics", McGraw Hill Education
2. Robert S. Witte and John S. Witte, "Statistics", Wiley Publications
3. U. Dinesh Kumar, "Business Analytics: The Science of Data-Driven Decision Making", Wiley India

Reference Books:

1. Seema Acharya and Subhashini Chellappan, "Big Data and Analytics", Wiley India
4. Allen B. Downey, "Think Stats: Exploratory Data Analysis in Python", Green Tea Press

E-Resources:

1. NPTEL Course on "Introduction to Data Analytics" (IIT Madras Track) Link: nptel.ac.in
2. NPTEL Course on "Data Analytics with Python" (IIT Roorkee Track)
Link: <https://nptel.ac.in/courses/106107220>
3. NPTEL Course on "Business Intelligence & Analytics" (IIT Madras Track)
Link: https://onlinecourses.nptel.ac.in/noc25_cs09/preview
4. NPTEL Course on "Business Analytics for Management Decision" (IIT Kharagpur Track)
Link: <https://nptel.ac.in/courses/110105089>
5. Coursera: "Google Data Analytics Professional Certificate" Link: coursera.org
edX: "Data Science: Statistics and Machine Learning" by Harvard University
Link: edx.org

E-Books

1. Allen B. Downey – Think Stats: Exploratory Data Analysis in Python (Open Access)
Link: greenteapress.com.
2. EMC Education Services – Data Science and Big Data Analytics (Open Academic Archive)
Link: archive.org

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Open Elective – III (Green Building)							Code: ALOE503B		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	-	-	50	50	-	100
Prerequisites:									
Basic environmental engineering, building materials & construction, engineering chemistry/ environmental science, basic knowledge of energy and sustainability concepts.									
Course Objectives:									
1. To equip students with the principles of sustainable building design, resource-efficient construction, and green building practices.									
2. To provide students with knowledge of energy-efficient technologies, water and waste management, sustainable materials, and green building rating systems.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the concepts, principles, benefits, and environmental impacts associated with green buildings and sustainable development.								
CO2	Assess building orientation, climate-responsive planning, landscaping, green roofs, and green walls for improving environmental performance.								
CO3	Evaluate building energy consumption and recommend energy-efficient strategies, HVAC optimization, renewable energy systems, and conservation measures.								
CO4	Design suitable water conservation, rainwater harvesting, greywater recycling, waste management, and sustainable drainage solutions for buildings.								
CO5	Select appropriate sustainable building materials and assess indoor environmental quality based on thermal comfort, indoor air quality, lighting, and acoustics.								
CO6	Compare major green building rating systems such as IGBC, GRIHA, and LEED and apply their principles to assess building sustainability.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Green Buildings: Definition, concept, and need of green buildings, Sustainable development principles, Environmental impacts of conventional buildings, Benefits of green buildings.								05
2.	Sustainable Planning & Architecture: Sustainable planning, Orientation and climate-responsive design, Landscape planning, Green roofs and walls.								05
3.	Energy Efficiency in Buildings: Energy consumption in buildings, Energy-efficient building design, HVAC optimization, Renewable energy systems (solar, wind), Energy audit and conservation techniques.								04
4.	Water & Waste Management: Water conservation techniques, Rainwater harvesting systems, Greywater recycling, Waste management in buildings, Sustainable drainage systems.								04

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5.	Sustainable Materials & Indoor Environmental Quality: Eco-friendly building materials, Low embodied energy materials, Recycled and locally available materials, Indoor air quality (IAQ), Thermal comfort, lighting, and acoustics.	04
6.	Green Building Rating Systems & Regulations: Overview of rating systems: Indian Green Building Council (IGBC), Green Rating for Integrated Habitat Assessment (GRIHA), Leadership in Energy and Environmental Design (LEED)	04
TOTAL		26
Teamwork : (Any 10)		
1. Study any IGBC/GRIHA certified building and identify the sustainable features adopted. 2. Study how sustainable development principles have been implemented in any residential, commercial, or institutional building. 3. Study a construction project and identify its environmental impacts. Suggest green alternatives to reduce these impacts. 4. Analyze building designed using passive architectural principles. 5. Study the site planning of a green campus, township, or commercial complex. 6. Study an existing building incorporating green roofs or vertical gardens. 7. Study an energy-efficient building and identify passive design strategies adopted. 8. Study a building utilizing renewable energy systems and evaluate their benefits. 9. Analyze an energy audit report (or published case study) and summarize the recommended energy-saving measures. 10. Study water conservation measures implemented in any green building. 11. Study a residential or institutional building with rainwater harvesting and grey water reuse systems. 12. Study the waste management practices of a smart city, residential township, or institutional campus. 13. Study a building that has extensively used sustainable building materials. 14. Perform a literature review on the life cycle assessment of one construction material. 15. Study an office, hospital, educational building, or green building focusing on indoor environmental quality improvements. 16. Compare two certified buildings, each evaluated under different rating systems (e.g., IGBC vs LEED or GRIHA vs IGBC). 17. Study the certification journey of an IGBC or GRIHA certified building.		
Text Books:		
1. K.S. Jagadeesh, "Alternative Building Materials and Technologies", New Age International. 2. C.J. Kibert, "Sustainable Construction: Green Building Design and Delivery", Wiley. 3. Charles J. Kibert, "Green Buildings: Principles and Practices", Island Press.		

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Environmental Legislations & Standards:

Indian Regulations

1. Environment (Protection) Act, 1986
2. Energy Conservation Act, 2001
3. National Building Code (NBC) of India
4. Eco-Niwas Samhita (Energy Conservation Building Code – Residential)

Standards & Guidelines

1. Energy Conservation Building Code (ECBC)
2. GRIHA & IGBC rating guidelines
3. LEED certification standards
4. Bureau of Energy Efficiency (BEE) norms

Reference Books:

1. O.H. Koenigsberger, "Manual of Tropical Housing and Building", Orient BlackSwan
2. G.Z. Brown and Mark DeKay, "Sun, Wind & Light", Wiley
3. Laurie Baker, "Building with Earth", Centre for Science and Environment
4. Indian Green Building Council, "IGBC Manuals and Guidelines", CII – Indian Green Building Council

E-Resources:

1. Indian Green Building Council - <https://igbc.in>
2. Green Rating for Integrated Habitat Assessment - <https://grihaindia.org>
3. U.S. Green Building Council - <https://usgbc.org>
4. NPTEL Green Building courses - <https://nptel.ac.in>
5. Ministry of Environment, Forest and Climate Change - <https://moef.gov.in>

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Open Elective – III (Electrical Mobility)							Code: ALOE503C		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	-	-	50	50	-	100
Prerequisites:									
Basic Electrical and Electronics Engineering.									
Course Objectives:									
1. To apply fundamental principles of electric mobility to interpret EV architectures, components and applications. 2. To utilize energy storage and battery management concepts to evaluate battery performance, charging, and safety. 3. To implement basic concepts of EV powertrains, electric drives, regenerative braking, and charging infrastructure. 4. To integrate smart charging, vehicle-to-grid, IoT, and emerging technologies for sustainable electric mobility.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the concepts, architecture, and applications of Electric and Hybrid Electric Vehicles.								
CO2	Identify the suitable energy storage systems used in electric vehicles.								
CO3	Illustrate battery charging methods, battery management systems, and SoC estimation techniques.								
CO4	Interpret hybrid powertrain configurations, operating modes, and regenerative braking.								
CO5	Demonstrate the use of electric drives, charging levels, charging standards, and EV charging equipment.								
CO6	Describe EV charging technologies and grid integration concepts such as G2V, V2G, V2H, V2B, and V2V.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Electric Mobility: Need for electric mobility, evolution of EVs, advantages and challenges, environmental and economic aspects, EV vs conventional vehicles, types of EVs: BEV, HEV, PHEV and fuel-cell vehicles, basic EV architecture and major components.								04
2.	Energy Storage Systems: Energy storage requirements, battery terminology and specifications, Li-ion batteries and their types, basic battery characteristics, battery alternatives: solid-state, Aluminium-air, fuel cell and supercapacitor, battery–supercapacitor hybrid system, selection of energy storage system.								04

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3.	Battery Charging and Management: EV charging basics, AC and DC charging, charging methods and levels, charging time and factors affecting charging, Battery Management System (BMS), functions of BMS, State of Charge (SoC), State of Health (SoH), State of Power (SoP), cell balancing, battery thermal management and safety.	05
4.	EV Powertrain and Electric Drives: EV powertrain architecture, energy flow in EVs, vehicle performance and basic tractive effort, electric motors used in EVs: BLDC and PMSM, motor selection, basic drive control, regenerative braking and its benefits.	04
5.	EV Charging Infrastructure: EV charging infrastructure, charging levels, AC/DC chargers, EVSE, charging connectors and standards: CCS, CHAdeMO, SAE J1772, Bharat AC/DC, basic charging station components, installation and safety considerations.	04
6.	Smart and Emerging Electric Mobility: Grid-to-Vehicle (G2V), Vehicle-to-Grid (V2G), Vehicle-to-Home (V2H), Vehicle-to-Building (V2B), Vehicle-to-Vehicle (V2V), smart charging, wireless charging, battery swapping, energy management, IoT and digital technologies in EVs, future trends and challenges.	05
TOTAL		26

Teamwork :

1. Study the architecture of an Electric Vehicle (EV) and identify the functions of major components such as battery, BMS, motor, inverter, charger, controller and sensors.
2. Compare 3–5 EVs available in India based on battery capacity, motor power, driving range, charging time, efficiency, cost and other key specifications.
3. Study and compare different energy storage technologies such as Li-ion batteries, solid-state batteries, fuel cells and supercapacitors based on energy density, charging time, life, cost, safety and applications.
4. Visit an EV charging station and study the charger type, AC/DC charging, charging level, connector/standard, power rating, and charging time and safety provisions.
5. Prepare a basic layout of an EV charging station showing charging points, power supply, protection system, parking area, cable routing, safety provisions and user facilities.
6. Study smart EV charging and Vehicle-to-Grid (V2G) concepts, including G2V, V2G, V2H and V2B, and identify their applications in smart grids and buildings.
7. Collect and analyze EV performance or charging data using Excel/Python/MATLAB and study parameters such as battery capacity, range, charging time and energy consumption.
8. Design a conceptual IoT-based EV monitoring system showing sensors, communication network, cloud platform and user interface for monitoring SoC, temperature, charging status and energy consumption.
9. Study regenerative braking in EVs and prepare an energy-flow diagram. Analyze energy recovery under different braking conditions using numerical calculations or simulation.
10. Study an emerging EV technology such as battery swapping, wireless charging, solid-state batteries, autonomous EVs, solar charging or second-life batteries and evaluate its technical, economic and environmental benefits.

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Text Books:

1. James Larminie and John Lowry, "Electric Vehicle", John Wiley & Sons, 2012.
2. Ronald K. Jurgen, "Electric and Hybrid-Electric Vehicles", SAE International.
3. K. T. Chau, "Energy Systems for Electric and Hybrid Vehicles", The Institution of Engineering and Technology.
4. D. A. J. Rand, R. Woods, and R. M. Dell, "Batteries for Electric Vehicles", Research Studies Press Ltd., New York, John Wiley & Sons.
5. "Electric & Hybrid Vehicles – Design Fundamentals", CRC Press.

Reference Books:

1. Mehrdad Ehsani, Yimin Gao, and Ali Emadi, "Modern Electrical Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.
2. Junwei Lu and Jahangir Hossain et al. (Eds.), "Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid", IET Digital Library.
3. Tom Denton, "Automobile Electrical and Electronic Systems", SAE International Publications.
4. C. Mi, M. A. Masrur, and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
5. Mark Warner, "The Electric Vehicle Conversion Handbook", HP Books, 2011.

E-Resources:

1. <https://www.theiet.org/resources/books/transport/vehicle2grid.cfm>
2. <https://www.sae.org/publications/books/content/pt-143.set/>
3. <http://nptel.ac.in/courses/108103009/>

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Open Elective – III (Introduction to Stock Market)							Code: ALOE503D		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	-	-	50	50	-	100
Prerequisites:									
Basic knowledge of economics and financial systems, Familiarity with percentage calculations and simple mathematics, Interest in investing and financial markets.									
Course Objectives:									
1. To understand the structure and functioning of financial and stock markets along with investor psychology.									
2. To apply candlestick patterns and indicators for identifying market trends.									
3. To understand the fundamentals of option is trading and option pricing concepts.									
4. To develop short-term and long-term investment strategies using fundamental and technical analysis.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the functioning of financial markets using fundamental analysis								
CO2	Analyze stock price movements using candlestick patterns for trading decisions.								
CO3	Analyze stock price movements using technical indicators for trading decisions.								
CO4	Describe the concepts of derivatives and option trading.								
CO5	Apply the strategies for option trading.								
CO6	Apply investment strategies based on market analysis.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Fundamental Analysis and Investor Psychology: Introduction to Financial Markets, Primary and Secondary Markets, Market Participants, Stock Exchanges, SEBI and Regulatory Framework, Investment vs Trading, Understanding Business Models, Reading Financial Statements (Balance Sheet, Profit & Loss Account, Cash Flow Statement), Fundamental Ratios (EPS, PE Ratio, PB Ratio, ROE, ROCE, Debt-Equity Ratio), Sector Analysis, Economic Indicators, Investor Psychology, Market Emotions (Fear & Greed), Behavioral Biases, Risk Management Principles.								06
2.	Technical Analysis using Candlestick Charts: Introduction to Technical Analysis, Dow Theory, Support and Resistance, Trend Analysis, Price Action Concepts Candlestick Anatomy: Single Candlestick Patterns (Doji, Hammer, Shooting Star, Marubozu, Spinning Top), Double Candlestick Patterns (Bullish & Bearish Engulfing, Harami, Piercing Pattern, Dark Cloud Cover), Triple Candlestick Patterns (Morning Star, Evening Star, Three White Soldiers, Three Black Crows), Gap Analysis, Trend Reversal and Continuation Patterns.								04

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3.	Technical Analysis using Indicators: Technical Indicators : Moving Averages (SMA, EMA), MACD, RSI, Stochastic Oscillator, Bollinger Bands, VWAP, ADX, ATR, Volume Analysis, Fibonacci Retracement, Pivot Points, Trend Confirmation, Indicator-Based Trading Strategies, Combining Multiple Indicators, Entry and Exit Rules, Backtesting Concepts.	04
4.	Introduction to Derivatives and FNO: Introduction to Derivatives, Futures and Options, Types of Options (Call and Put), Option Terminology (Strike Price, Expiry, Premium, Lot Size, Open Interest), Intrinsic and Time Value, ITM, ATM, OTM Options, Option Chain Analysis, Greeks (Delta, Gamma, Theta, Vega, Rho - Basic Concepts), Option Pricing Factors, Option Expiry and Settlement Process.	04
5.	Introduction to Option Trading Strategies: Option Buying vs Option Selling, Risk and Reward Analysis, Long Call, Long Put, Covered Call, Cash Secured Put, Bull Call Spread, Bear Put Spread, Bull Put Spread, Bear Call Spread, Iron Condor (Basic Concept), Straddle and Strangle (Introduction), Position Sizing, Stop Loss Techniques, Capital Management, Risk Management in Options Trading.	04
6.	Short-Term and Long-Term Trading & Investment Strategies: Swing Trading, Positional Trading, Intraday Trading (Overview), Momentum Trading, Breakout Trading, Trend Following Strategies, Portfolio Building, Value Investing, Growth Investing, Dividend Investing, SIP in Equity, Asset Allocation, Diversification, Trading Plan Development, Trading Journal, Performance Evaluation, Common Mistakes Made by Traders and Investors, Ethics in Financial Markets.	04
Total		26
Term Work:		
Sr. No.	Title	Proposed Activities
1.	Stock Market Basics & Trading Platform	Introduction to NSE & BSE, SEBI, Demat & Trading Accounts, Market Participants, Creating a Paper Trading Account.
2.	Fundamental Analysis – I	Reading Financial Statements, EPS, PE Ratio, Book Value, Market Capitalization, Sector Analysis
3.	Fundamental Analysis – II & Investor Psychology	Company Comparison, Economic Indicators, Market Cycles, Fear & Greed, Trading Discipline
4.	Candlestick Analysis – I	Candlestick Anatomy, Doji, Hammer, Shooting Star, Marubozu, Trend Identification
5.	Candlestick Analysis – II	Bullish/Bearish Engulfing, Morning Star, Evening Star, Support & Resistance using Charts
6.	Technical Indicators – I	SMA, EMA, Volume Analysis, Trend Identification using TradingView

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Sr. No.	Title	Proposed Activities
7.	Technical Indicators – II	RSI, MACD, Bollinger Bands, VWAP, Indicator-based Entry & Exit
8.	Option Trading Fundamentals	Call & Put Options, Strike Price, Premium, Expiry, Option Chain Analysis
9.	Option Buying Strategies	Long Call, Long Put, Break-even Calculation, Risk & Reward Analysis
10.	Option Selling Strategies	Covered Call, Cash Secured Put, Bull Call Spread, Bear Put Spread
11.	Short-term Trading Strategies	Intraday (Concept), Swing Trading, Breakout Trading, Risk Management
12.	Long-term Investment Strategies	Value Investing, Growth Investing, Dividend Investing, Portfolio Diversification
Students should spend most of the session on: 1. Live chart analysis using Trading View or similar platforms. 2. Analyzing real companies using NSE/BSE financial data. 3. Paper trading (no real money involved). 4. Maintaining a trading journal. 5. Presenting and reviewing trading decisions.		
Reference Books: 1. John J. Murphy, "Technical Analysis of the Financial Markets", Pearson. 2. Benjamin Graham, "The Intelligent Investor", Harper Business. 3. Martin J. Pring, "Technical Analysis Explained", McGraw-Hill. 4. Sheldon Natenberg, "Option Volatility and Pricing", McGraw-Hill. 5. Aswath Damodaran, "Investment Valuation", Wiley. Alexander Elder, "Trading for a Living", Wiley.		
E-Resources: 1. National Stock Exchange (NSE) Learning Portal – https://www.nseindia.com 2. Bombay Stock Exchange (BSE) Investor Education – https://www.bseindia.com 3. SEBI Investor Education – https://investor.sebi.gov.in 4. NISM (National Institute of Securities Markets) – https://www.nism.ac.in 5. Zerodha Varsity – https://zerodha.com/varsity 6. Investopedia – https://www.investopedia.com		

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Open Elective – III (Patent Law for Engineers and Scientists)							Code: ALOE503E		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	-	-	50	50	-	100
Prerequisites:									
Basic understanding of engineering/scientific concepts and technological innovation, Basic skills in technical reading, documentation, and report writing.									
Course Objectives:									
1. To understand the importance of Intellectual Property Rights (IPR) and patents. 2. To identify patentable and non-patentable inventions based on patentability criteria. 3. To conduct prior-art and patent searches using public patent databases. 4. To draft a basic patent specification, including claims and abstract. 5. To understand and apply the complete patent filing, examination, and granting process in India. 6. To analyze engineering case studies involving patents, innovation, and commercialization.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Apply the provisions of the Indian Patent Law to engineering inventions.								
CO2	Perform prior-art and patent searches using standard patent databases.								
CO3	Analyze the patentability, filing, examination, and grant process under the Indian Patent Act.								
CO4	Evaluate patent infringement, licensing, technology transfer, and commercialization issues.								
CO5	Draft a patent specification, including claims and abstract, in compliance with patent law.								
CO6	Develop a patent application for an innovative engineering solution following legal and procedural requirements.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Intellectual Property Rights and Patents: Introduction to Intellectual Property Rights (IPR), significance of IPR in engineering, innovation and entrepreneurship, types of IPR, concept and objectives of patents, patentability criteria (novelty, inventive step and industrial applicability), patentable and non-patentable inventions under the Indian Patent Act, 1970, patents versus research publications and products, role of patents in technology commercialization and startup ecosystem. Case Study: Patentability analysis of a simple engineering innovation.								05
2.	Indian Patent Law and Prior-Art Search: Overview of the Indian Patent Act, 1970 and its amendments, objectives and scope of patent law, rights and duties of inventors, overview of WIPO, Patent Cooperation Treaty (PCT) and international patent systems, prior-art search techniques, patent classification systems, patent search using Google Patents, InPASS, Espacenet, and WIPO PATENTSCOPE, novelty assessment and patent landscape analysis. Case Study: Prior-art search and novelty analysis of an engineering invention.								04

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3.	Patent Drafting: Structure and components of a patent specification including title, field of invention, background, prior art, problem statement, objectives, summary of invention, brief description of drawings, detailed description, claims, abstract, and drawings. Principles of claim drafting, dependent and independent claims, patent drafting guidelines, common drafting errors, and patent documentation for engineering innovations. Case Study: Drafting of a patent specification for a smart engineering product.	05
4.	Patent Filing, Examination and Grant: Patent filing procedure in India, provisional and complete specification, online filing process, statutory forms, publication of patent application, request for examination, First Examination Report (FER), response to objections, hearing process, patent grant, renewal, restoration, opposition, and maintenance of patents under the Indian Patent Act. Case Study: Patent filing and grant timeline of an Indian engineering patent.	04
5.	Patent Commercialization and Legal Issues: Patent ownership, licensing, assignment, technology transfer, patent valuation, startup and university patents, patent infringement, remedies and dispute resolution, freedom-to-operate (FTO), patent analytics, commercialization strategies, and ethical issues in patent protection, Case Study: Commercialization of a patented engineering innovation.	04
6.	Emerging Technologies and Patent Case Studies: Patents in Artificial Intelligence, Machine Learning, Internet of Things (IoT), Robotics, Semiconductor Technology, Biotechnology, Software, Green Technologies, and Industry 4.0, AI-generated inventions, recent developments in patent law, international patent trends, patent portfolio management, and innovation-driven entrepreneurship. Case Study: Analysis of landmark patent disputes such as Apple vs Samsung or an Indian engineering innovation, along with preparation of a basic patent draft for an engineering solution.	04
TOTAL		26
Term Work:		
Students shall complete the following practical, activity-oriented assignments based on a selected engineering innovation/project: 1. Identify suitable IP protection for an engineering innovation and assess basic patentability criteria. 2. Conduct patent searches using Google Patents, IP India, WIPO PATENTSCOPE and Espacenet and analyze the novelty of the selected innovation. 3. Identify a copyrightable work such as software, technical content or digital work and prepare/undertake the copyright registration process.		

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Term Work:

4. Develop a product/start-up brand, conduct trademark search, identify the appropriate class and prepare a basic trademark application.
5. Identify protectable visual features of an engineering product, conduct design search and prepare a basic design registration application.
6. Prepare a basic patent specification including title, background, objectives, description, drawings, abstract and claims for an engineering innovation.
7. Prepare a mock provisional/complete patent application and study the filing, publication, examination, FER, response and grant process in India.
8. Study the PCT route and prepare a mock PCT application based on the selected engineering invention.
9. Analyze patents in a selected emerging technology area and identify major patent holders, technology trends and basic FTO considerations.
10. Develop an IP portfolio for the selected innovation covering patent, copyright, trademark/design and propose a basic commercialization strategy.

Text Books:

1. P. Narayanan, "Patent Law", Eastern Law House.
2. Prabuddha Ganguli, "Intellectual Property Rights: Unleashing the Knowledge Economy", McGraw-Hill.
3. N. S. Gopalakrishnan and T. G. Agitha, "Principles of Intellectual Property", Eastern Book Company.
4. Government of India, "The Patents Act, 1970 (as amended) and The Patents Rules, 2003 (as amended)", Government of India.

Reference Books:

1. David Pressman, "Patent It Yourself", NOLO Publications.
2. WIPO, "WIPO Intellectual Property Handbook: Policy, Law and Use", World Intellectual Property Organization.
3. Indian Patent Office, "Manual of Patent Office Practice and Procedure", Office of the Controller General of Patents, Designs & Trade Marks (CGPDTM), Government of India.
4. Alexander I. Poltorak and Paul J. Lerner, "Essentials of Intellectual Property", John Wiley & Sons.

E-Resources:

1. **Patent Law for Engineers and Scientists** – NPTEL (IIT Madras):
<https://nptel.ac.in/courses/110106081>
2. **Intellectual Property** – NPTEL (IIT Madras):
<https://nptel.ac.in/courses/109106137>

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V			
Course: Robot Operating System							Code: RAAE502			
Teaching Scheme (Hrs./Week)				Evaluation Scheme						
Lecture	Practical	Tutorial	Credit	IE	MTE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	-	-	50	50
Prerequisites:										
Operating System Knowledge(Linux OS), Programming Skills (Python, C++)										
Course Objectives:										
1. Understand ROS fundamentals for robotic system development.										
2. Understand ROS communication mechanisms.										
3. Apply ROS tools for robot programming.										
4. Develop robot models using ROS visualization frameworks.										
5. Implement mapping using ROS navigation packages.										
6. Integrate robotic hardware with ROS.										
Course Outcomes:										
CO1	Explain ROS architecture, communication concepts, Linux commands.									
CO2	Apply ROS tools to create nodes, topics, services, robot applications									
CO3	Build robot models using URDF, RViz, Gazebo simulation tools.									
CO4	Implement mobile robot simulation using TurtleBot3 with sensor integration.									
CO5	Analyze SLAM, localization, autonomous navigation using ROS navigation packages.									
CO6	Integrate hardware interfaces with ROS for robotic system deployment.									
Course Contents:										
Unit	Description									Duration (Hrs.)
1.	ROS Fundamentals & Architecture: Introduction and overview to ROS, its Architecture: Nodes, Topics, Services, Actions, Parameters, ROS packages, Communication Systems: ROS Master, DDS – Data Distribution Service, Basic Linux commands.									04
2.	Practical on Turtlesim: Turtlesim package, controlling turtle using ROS 2 topics and services and nodes, Writing ROS Nodes (Python/C++), Publisher–Subscriber communication. URDF and ROS 2 Visualization Tools: URDF and Xacro for robot modeling, Using RViz2 for robot visualization Using Gazebo for simulation, using custom world in gazebo Using rqt_graph, ros2 topic, ros2 service, and tools									04
3.	Mobile Robot Simulation (turtlebot 3): TurtleBot3 setup (simulation), Launching TurtleBot3 in Custom Gazebo world, Teleportation using teleop key ,custom launch file and sensor data visualization in Rviz									04
4.	Custom Robot Design & Simulation: Designing custom robot (URDF/Xacro) using fusion 360/SolidWorks, Simulation of custom robot in Gazebo, making custom gazebo world , launching robot in custom world. Simulation and sensors: Sensor integration and plugins: LiDAR, Camera, IMU, Running robot in custom Gazebo world, sensor data visualization in rviz.									04

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5.	Mapping, and Navigation: Launching real-world-like simulations in Gazebo, including custom world creation, performing SLAM using the slam_toolbox, implementing autonomous navigation with the Nav2 stack, along with map generation, saving, and localization	04
6.	Hardware Integration: Hardware Integration in ROS 2: Interfacing with sensors: IMU, LiDAR, Cameras, Actuators: motors, encoders, grippers, controller (Arduino rpi pico) Using ros2_control and hardware interfaces	06
TOTAL		26
List of Experiments: (Any Eight)		
1. Install and Configure ROS 2 Humble on Ubuntu. 2. Implement Publisher/Subscriber and Service/Client in ROS 2. 3. Create a Custom Turtle Controller Using Publisher and Service. 4. Create and Visualize a Custom Robot Model in RViz2. 5. Simulate TurtleBot3 in Gazebo and Control via Teleop. 6. Perform Mapping and Autonomous Navigation with TurtleBot3. 7. Integrate and Simulate a Robotic Arm with MoveIt 2. 8. Simulate a Vision-Based Pick and Place Task. 9. Integrate and Read Data from a Real Sensor in ROS 2. 10. Mini Project: Full-system integration, Planning, design, implementation, Documentation and testing.		
Text Books:		
1. Morgan Quigley, Brian Gerkey, William D. Smart, "Programming Robots with ROS" O'REILLY. 2. Aaron Martinez, Enrique Fernandez, "Learning ROS for Robotics Programming" Packt Publication. 3. Jason M. O'Kane "A Gentle Introduction to ROS" ISBN 978-14-92143-23-9.		
Reference Books:		
1. Jason M. O'Kane, A Gentle Introduction to ROS, independently published, ISBN 9781492143239. 2. Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners", Apress Publication, ISBN: 978. 3. Morgan Quigley, Brian Gerkey, William D. Smart, "Programming Robots with ROS", O'Reilly Media Inc., ISBN: 9781449325503. 4. C. Fairchild, T. L. Harman, "ROS Robotics by Example" Pakt Publishing, ISBN: 9781785286704.		
E-Resources:		
1. Online books: https://gazebo.org/tutorials?tut=ros_gentle_introduction 2. Official Documentation and Tutorials: https://wiki.ros.org/ , https://docs.ros.org/en/foxy/ 3. Online Courses: https://www.theconstructsim.com/ros-courses/		

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Internship – IV							Code: RAIN504		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	-	-	02	-	-	25	-	-	25
Preamble:									
Internships serve as vital educational and career development experiences, offering practical exposure in a specific field. Employers seek individuals who possess the necessary skills and an understanding of industry environments, practices, and cultures. This internship is designed as a structured, short-term, supervised training program, often centered on specific tasks or projects with clear timelines. The primary goal is to immerse technical students in an industrial setting, providing experiences that cannot be replicated in the classroom. This exposure aims to develop competent professionals who understand the social, economic, and administrative factors influencing the operations of industrial organizations.									
Course Objectives:									
1. Exposure to students to the industrial environment, which cannot be provided in the classroom and hence creating deployable professionals for the industry.									
2. Learn to implement the technical knowledge in real industrial situations.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Gain exposure to industry practices and understand how academic concepts are applied in professional settings.								
CO2	Develop and demonstrate effective communication and teamwork skills within a work environment.								
CO3	Improve your problem-solving and time management skills by working in real-world industry settings.								
Internship Requirements									
1. Internship Duration: It is mandatory for all students to undergo an internship after every semester during vacations for the duration of 3 to 5 weeks. Internships completed during this period will be considered for the assessment of Term Work (TW).									
2. Internship Opportunities: Students can explore various opportunities for internships at:									
a. Industries									
b. Research labs or organizations									
c. Collegiate clubs									
d. In-house research projects									
e. Online internships									
3. Support and Assistance: Students can seek assistance for securing internships from:									
a. The Training and Placement cell, along with departmental coordinators									
b. Department or institute faculty members									
c. Personal contacts									
d. Directly connecting with industries or organizations									
4. Request Letter: Once an industry, research organization, or collegiate club is identified, students must obtain a request letter from the concerned department or placement office. This letter, in the standard format must be duly signed by the authority, should be addressed to the HR manager or relevant authority.									

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5. **Request Letter:** Once an industry, research organization, or collegiate club is identified, students must obtain a request letter from the concerned department or placement office. This letter, in the standard format must be duly signed by the authority, should be addressed to the HR manager or relevant authority.
6. **Confirmation Letter:** Students must submit the confirmation letter from the industry, research organization, or collegiate club to the Internship Coordinator and the Head of Department (HOD) office.
7. **Joining Report:** Upon commencing the internship, students must submit the joining report, joining letter, or a copy of the confirmation email to the Internship Coordinator and the HOD office.
8. **Faculty Mentor:** A faculty member will be assigned as a mentor to a group of students. The mentor will be responsible for monitoring, evaluating, and assessing student internship activities. The faculty mentor is also required to visit the internship location and submit formal feedback to the Internship Coordinator.
9. **Faculty Visits:** Faculty members are advised to visit the internship site once or twice during the internship period to monitor progress.
10. **Progress Report:** Students must submit progress report fortnightly to their faculty guide and the final internship report to the Internship Coordinator and department office.
11. **Evaluation Report:** After the completion of the internship, the mentor, along with the assessment panel members, should submit the evaluation report of the students to the department office and the Internship Coordinator.
12. **Internship Certificate:** Students must receive the Internship Certificate from the industry and submit it to the Internship Coordinator and department office.
13. **Presentation and Assessment:** Students are required to give a presentation on their internship work as part of the term work. The internship diary and report will also be verified and assessed.

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SYLLABUS
SEMESTER - VI

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Industrial Automation							Code: RAPC611		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites:									
Basic Electrical and Electronics Engineering, Fundamentals of Sensors and Instrumentation, Basics of Control Systems									
Course Objectives:									
1. Understand the architecture and working principles of industrial automation systems. 2. Understand the working principles, selection, and applications of industrial sensors and actuators used in automation systems. 3. Demonstrate programming skills in PLCs and industrial automation controllers. 4. Design SCADA, HMI, and industrial communication systems used in automation. 5. Understand industrial automation systems and the integration of robotics in manufacturing processes. 6. Implement fundamentals of Industrial automation Industry 4.0 and smart manufacturing.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Understand basic concepts, architecture, and applications of industrial automation systems.								
CO2	Explain the functions and applications of sensors, actuators, and industrial control devices used in automation systems.								
CO3	Apply automation and robotics integration concepts for industrial manufacturing and material handling applications.								
CO4	Develop PLC ladder logic programs for industrial automation tasks.								
CO5	Design SCADA and HMI systems for industrial monitoring and control applications.								
CO6	Apply Industry 4.0 concepts and smart manufacturing technologies to enhance industrial automation systems.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Industrial Automation Evolution of automation, need and scope of industrial automation, fixed and flexible automation, automation pyramid, components of automation systems, process and discrete automation, automation in manufacturing industries, automation standards and safety practices								06
2.	Industrial Sensors and Actuators Industrial sensors: proximity sensors, inductive, capacitive, photoelectric, ultrasonic, temperature, pressure, flow and level sensors. Actuators: pneumatic, hydraulic and electric actuators. Solenoid valves, relays, contactors, stepper motors, servo motors, industrial drives, selection criteria and industrial applications.								07

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3.	Industrial Automation Systems and Robotics Integration Automated material handling systems, automated assembly systems, CNC and DNC systems, AGVs, automated inspection systems, robotics in industrial automation, integration of robots with PLC and sensors, machine vision basics, case studies in automotive, packaging, food processing and process industries.	06
4.	Programmable Logic Controllers (PLC) Introduction to PLC, PLC architecture, I/O modules, memory organization, PLC scan cycle, PLC programming languages (IEC 61131-3), ladder logic diagrams, timers, counters, sequencing, interlocks, analog I/O handling, troubleshooting and industrial applications. Development of PLC programs for motor control, conveyor systems and process automation.	07
5	SCADA, HMI and Industrial Communication SCADA architecture and functions, HMI design principles, data acquisition systems, alarms and trends, industrial communication systems, RS-232, RS-485, Modbus, Profibus, CAN bus, Ethernet/IP, OPC-UA.	07
6.	Industry 4.0 and Smart Manufacturing Industrial Internet of Things (IoT), cloud-based automation, edge computing, digital twin concept, predictive maintenance, data analytics in automation, cyber-physical systems, smart sensors, MES systems, AI applications in automation, future trends in industrial automation and smart manufacturing.	06
TOTAL		39

Text Books:

1. Frank D. Petruzella, Programmable Logic Controllers, McGraw Hill Education.
2. S. Brian Morriss, Automated Manufacturing Systems, McGraw Hill.
3. Krishna Kant, Computer Based Industrial Control, PHI Learning.
4. John W. Webb and Ronald A. Reis, Programmable Logic Controllers: Principles and Applications, PHI.
5. Stenerson Jon, Industrial Automation and Process Control, Pearson Education.

Reference Books:

1. Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson.
2. Hugh Jack, Automating Manufacturing Systems with PLCs, Industrial Text Company.
3. Bolton W., Programmable Logic Controllers, Elsevier.
4. Richard L. Shell and Ernest L. Hall, Handbook of Industrial Automation, CRC Press.
5. Bela G. Liptak, Instrument Engineers' Handbook: Process Control and Optimization, CRC Press.
6. K.S. Fu, R.C. Gonzalez and C.S.G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill.
7. Alciatore David and Histan Michael, Introduction to Mechatronics and Measurement Systems, McGraw Hill.

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E-Resources:

1. Siemens PLC and SCADA Training Resources: <https://www.sitrain-learning.siemens.com>
2. Rockwell Automation Learning Portal: <https://www.rockwellautomation.com/en-us/support/training.html>
3. Mitsubishi Electric Factory Automation Resources: <https://www.mitsubishielectric.com/fa>
4. Automation Direct PLC Learning Modules: <https://library.automationdirect.com/plc-learning-series>
5. FANUC and ABB Robotics Industrial Training Resources
https://www.fanucamerica.com/support/training?utm_source=chatgpt.com

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Industrial Automation Lab							Code: RAPC611P		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Basic Electrical Engineering, Digital Logic Fundamentals, Basic Programming, Sensors									
Course Objectives:									
1. Understand industrial automation components and PLC hardware. 2. Develop PLC programs using ladder logic. 3. Implement PLC-based automation and control systems. 4. Develop SCADA and HMI applications for industrial processes.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Identify and explain industrial automation components and PLC hardware.								
CO2	Develop PLC ladder programs using logic gates, timers, and counters.								
CO3	Implement PLC-based motor, traffic, colour, and geometry control systems.								
CO4	Develop PLC-based electro-pneumatic and electro-hydraulic control systems.								
List of Experiments									
Any EIGHT from the Following									
Expt. No.	Description							Duration (Hrs.)	
1.	Study of Industrial Automation Components and PLC Hardware							02	
2.	Development of Basic PLC Ladder Logic Programs using Logic Gates, Timers, and Counters							02	
3	Development of PLC-Based Motor Control and Protection System							02	
4.	Development of PLC-Based Traffic Light Automation System							02	
5.	Development of PLC-Based Colour identification System							02	
6.	Development of PLC-Based geometry identification System							02	
7.	Development of Electro-Pneumatic Control System using PLC							02	
8.	Development of Electro-Hydraulic Control System using PLC							02	
9.	Design SCADA Interface for Industrial Process Monitoring and Control							02	
10.	Design PLC–SCADA Communication using Modbus/Industrial Ethernet							04	
11.	Design HMI Design and Development for Industrial Automation Applications							04	
TOTAL							26		
Reference Books:									
1. Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson. 2. Hugh Jack, Automating Manufacturing Systems with PLCs, Industrial Text Company. 3. Richard L. Shell and Ernest L. Hall, Handbook of Industrial Automation, CRC Press.									
E-Resources:									
1. Industrial Automation Laboratory: https://ial-coep.vlabs.ac.in/									

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Robot Programming & Simulations							Code: RAPC612		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Introduction to Robotics & automation, Sensors, Robot Kinematics & Dynamics,									
Course Objectives:									
1. To understand industrial robot programming fundamentals. 2. To apply robot programming languages for industrial automation. 3. To develop robot programs using manufacturer-specific languages. 4. To perform offline robot simulation using industrial software. 5. To understand Collaborative Robots and their applications. 6. To integrate robotic vision with industrial robot applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain industrial robot architecture, coordinate systems, safety concepts.								
CO2	Apply VAL, VAL-II, RAPID, AML programming for industrial tasks.								
CO3	Develop robot programs using Karel, FANUC TP, KRL, INFORM, URScript.								
CO4	Perform offline robot simulation using industrial programming tools.								
CO5	Explain the fundamentals, architecture, safety, programming, and industrial applications of Collaborative Robots.								
CO6	Integrate ROS 2 packages for industrial manipulator applications.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Industrial Robots and Robot Programming History of industrial robotics: development milestones, and current use in manufacturing, Types of industrial robots, Basic robot structure, Coordinate systems, Basic motion and commands, Safety fundamentals								06
2.	VAL and VAL-II Programming: VAL — Language Background and Structure, VAL Motion and Handling Commands, VAL Auxiliary Commands and I/O, VAL Application Programs, VAL-II — Structured Programming Additions, VAL-II Advanced Features								06
3.	RAPID and AML Programming: RAPID — Modules, Tasks, and Data Types, RAPID Motion Instructions, RAPID Control Flow and I/O, RAPID Application Programming, AML — Structure and Core Concepts, AML Motion, Sensor, and Communication Commands								07
4.	Karel, FANUC TP and Other Industrial Robot Languages: Karel — Language Overview and Structure, Karel — Motion and I/O Instructions, FANUC TP — Teach Pendant Programming, FANUC TP — Control Flow and Applications, KRL — KUKA Robot Language Essentials, INFORM and URScript — Overview and Language Comparison								07
5.	Cobots Programming: Introduction to Cobots & Robotics Fundamentals, Cobots vs. traditional industrial robots, Cobot Hardware & System Architecture, Cobot Safety & Risk Assessment, Cobot Programming & End-of-Arm Tooling, Industrial Applications & Integration								06

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6.	ROS 2 Basics for Industrial Robotics: ROS 2 architecture: nodes, topics, services, actions, parameters, and TF2, Overview of robotic arm packages (MoveIt 2, ROS-Industrial), Kinematics and joint control, controlling robotic arms using ROS 2 nodes Robotic Arm with Vision System: Depth cameras and 3D sensors (e.g., RealSense), Object detection basics (OpenCV + ROS 2), Pick-and-place simulation using vision	07
TOTAL		39
Text Books:		
1. Cameron Hughes and Tracey Hughes, Robot Programming: A Guide to Controlling Autonomous Robots, 1st Ed., 2016. 2. Mikell P. Groover et al., Industrial Robotics: Technology, Programming, and Applications, 2nd Ed., McGraw-Hill, 2012. 3. S. R. Deb, Robotics Technology and Flexible Automation, McGraw-Hill, 2010. 4. Morgan Quigley, Brian Gerkey, William D. Smart, Programming Robots with ROS, O'Reilly Media, 2015. 5. Lentin Joseph, Robot Operating System (ROS) for Absolute Beginners, Apress, 2018.		
Reference Books:		
1. Bruno Siciliano et al., Robotics: Modelling, Planning and Control, Springer, 2009. 2. Morgan Quigley et al., Programming Robots with ROS, O'Reilly, 2015. 3. ROS 2 Documentation, MoveIt 2 Documentation, ABB RobotStudio Help, Universal Robots Academy, and KUKA XPERT 4. Aaron Martinez, Enrique Fernández, Learning ROS for Robotics Programming, Packt Publishing, 2015. 5. Anis Koubaa (Editor), Robot Operating System (ROS): The Complete Reference (Volume 1), Springer, 2016.		
E-Resources:		
1. FANUC Education: https://www.fanucamerica.com/solutions/education?utm_source=chatgpt.com 2. FANUC ROBOGUIDE: https://www.fanucamerica.com/products/robots/robot-simulation-software-FANUC-ROBOGUIDE?utm_source=chatgpt.com 3. KUKA.Sim: https://www.kuka.com/en-de/products/robot-systems/software/simulation-planning-optimization/kuka_sim?utm_source=chatgpt.com 4. Practical Programming https://youtu.be/iqBUpA7fg5E?si=h14DmTOi_IUg7CBy 5. ABB Robotics Library https://search.abb.com/library?utm_source=chatgpt.com 6. RoboDK Documentation https://robodk.com/doc/en?utm_source=chatgpt.com		

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Robot Programming & Simulations Lab							Code: RAPC612P		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	--	-	-	-	50	50
Prerequisites: Introduction to Robotics & automation, Sensors & Instrumentation, Robot Kinematics & Dynamics, Python.									
Course Objectives:									
1. Understand robot structure, coordinate systems, and teach pendant operations. 2. Develop robot programs using VAL, VAL-II, AML, and RAPID languages. 3. Implement robotic workcells and ROS 2 simulations for motion planning and industrial applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Identify robot components, coordinate frames, teach pendant functions, and programming languages.								
CO2	Develop and simulate robot programs for pick-and-place and basic industrial applications.								
CO3	Design and test collision-free robotic workcells using RoboDK, RobotStudio, and ROS 2 tools.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Identify robot parts, coordinate frames, and teach pendant functions								02
2.	Develop Basic Programs Using VAL, VAL-II, and AML								02
3.	Basic Programming on RAPID Language								02
4.	Programming the robot for pick and place operation using suitable robot								02
5.	Basic Programming on AML Language								02
6.	Build a basic workcell in RoboDK or RobotStudio and test collision-free motion								04
7.	Create a ROS 2 description, visualize it in RViz2, and understand Nav2/MoveIt2 flow								04
8.	Industrial visit on industrial applications of robots								06
TOTAL								26	
Reference Books:									
1. Bruno Siciliano et al., Robotics: Modelling, Planning and Control, Springer, 2009. 2. Morgan Quigley et al., Programming Robots with ROS, O'Reilly, 2015. 3. ROS 2 Documentation, MoveIt 2 Documentation, ABB RobotStudio Help, Universal Robots Academy, and KUKA XPERT 4. Aaron Martinez, Enrique Fernández, Learning ROS for Robotics Programming, Packt Publishing, 2015. 5. Anis Koubaa (Editor), Robot Operating System (ROS): The Complete Reference (Volume 1), Springer, 2016.									
E-Resources:									
1. Practical Programming: https://youtu.be/iqBUpA7fg5E?si=h14DmTOi_IUg7CBy									

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PROGRAM ELECTIVE – II
(Select any one course from the given Open
Elective Courses)

DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Additive Manufacturing							Code: RAPE604A		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites:									
Manufacturing Processes, Material Science and Engineering, Basics of CAD/CAM.									
Course Objectives:									
1. To introduce the fundamentals and industrial importance of Additive Manufacturing. 2. To study various additive manufacturing technologies and their working principles. 3. To understand materials used in AM including polymers, metals, ceramics, and composites. 4. To develop skills in CAD modeling, slicing, and process parameter optimization. 5. To explore industrial applications of AM in robotics, automation, aerospace, automotive, biomedical, and tooling sectors. 6. To impart knowledge about design for additive manufacturing (AM), sustainability, and future trends.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain fundamentals of Additive Manufacturing.								
CO2	Describe various Additive Manufacturing technologies and FDM processes.								
CO3	Select suitable materials for different applications.								
CO4	Demonstrate proficiency in operating FDM 3D printers.								
CO5	Analyze defects and perform post-processing, finishing and testing.								
CO6	Create Additive Manufacturing components for robotics and industrial applications.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Fundamentals of Additive manufacturing Definition and History of Additive Manufacturing, Differences between AM and traditional manufacturing, Role of RP in product development Limitations of 3D printing, Introduction to Additive Manufacturing: Industry 4.0, AM classification, digital workflow, applications in robotics and automation.							07	
2.	Types of Additive Manufacturing Technologies Stereolithography (SLA), Selective Laser Sintering (SLS), Fused Deposition, Modeling (FDM) Digital Light Processing (DLP) Electron Beam Melting, (EBM), Laminated Object Manufacturing (LOM), Introduction to FDM, Process, Process cycle, Application of FDM Process in robotics and industry							07	
3.	Material selection Material properties and selection criteria , Polymers, Metals, and Composites Materials for FDM Process, Types and Properties							07	
4.	FDM 3D Printer and CAD Software FDM 3D printer and its Parts, Printing Parameters, CAD software for AM Printing Software (Slicer),Steps in creating a prototype							06	

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5.	Post Processing Operations and Testing Materials, Defects and Post Processing in AM. Support removal and surface finishing, Heat treatment and annealing, Painting, plating, and other finishing methods, ASTM D standards for plastic testing	06
6.	Design and Case Study Design for Additive Manufacturing and Industrial Applications. Case study in robotics and mini project in FDM component.	06
TOTAL		39
Text Books:		
1. Ian Gibson, David W. Rosen and Brent Stucker, Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer. 2. Chee Kai Chua and Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific Publishing. 3. Amit Bandyopadhyay and Susmita Bose, Additive Manufacturing, CRC Press. 4. Chua C. K., Fundamentals of Additive Manufacturing and 3D Printing, World Scientific Publishing.		
Reference Books:		
1. Milan Brandt, Laser Additive Manufacturing: Materials, Design, Technologies, and Applications, Woodhead Publishing. 2. B. V. V. S. Prasad, Additive Manufacturing Processes, McGraw Hill Education. 3. Christopher Barnatt, 3D Printing: The Next Industrial Revolution, ExplainingTheFuture.com. 4. Martin Leary, Design for Additive Manufacturing, Elsevier Academic Press. 5. John O. Milewski, Additive Manufacturing of Metals: From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry, Springer.		
E-Resources:		
1. ASTM Additive Manufacturing Standards https://store.astm.org/additive-manufacturing-standards 2. SME Additive Manufacturing Resources https://www.sme.org/technologies/additive-manufacturing 3. MIT Additive Manufacturing Research https://additivemanufacturing.mit.edu 4. Additive Manufacturing Research https://www.autodesk.com/solutions/additive-manufacturing 5. ASTM Additive Manufacturing Center of Excellence: https://www.youtube.com/@astmadditivemanufacturingc1289		

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Additive Manufacturing Lab							Code: RAPE604AP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Basic CAD Modelling Knowledge, Engineering Drawing Fundamentals, Basic Manufacturing Processes.									
Course Objectives:									
1. Understand the fundamentals of FDM 3D printing technology.									
2. Develop basic CAD models for FDM printing.									
3. Understand slicing software and printing parameters.									
4. Develop skills in operating and maintaining FDM printers.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain FDM printer components, materials, and applications.								
CO2	Create CAD models suitable for FDM printing.								
CO3	Select appropriate slicing and printing parameters.								
CO4	Operate, calibrate, and maintain an FDM 3D printer.								
Any Eight From the Following									
Exp. No.	Description							Duration (Hrs.)	
1.	Study of FDM 3D Printer Parts, Applications, and Safety Guidelines							02	
2.	Study of FDM 3D Printing Filaments and their Applications							02	
3.	Filament Unloading, Nozzle Cleaning, and Basic Printer Maintenance							02	
4.	Create 3D Models for FDM Printing							02	
5.	Study of Slicing Software and Printing Parameters							02	
6.	Conversion of CAD Model to STL File and Slicing of Simple Components							02	
7.	Demonstration of Nozzle Calibration (Manual and Automatic) and Filament Loading Procedure (Demonstration / Simulation)							02	
8.	Development of Basic 3D Models Using CAD and FDM 3D Printing							02	
9.	Demonstration of Printed Object from Print Bed and Post-Processing Techniques							02	
10.	Design, Slicing, and Printing of Overhang Components with Support Structures							04	
11.	Design and Printing of Tensile Test Specimen as per ASTM D638 Standard							04	
TOTAL							26		
Text Books:									
1. Ian Gibson, David W. Rosen and Brent Stucker, Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer.									
2. Chee Kai Chua and Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific Publishing.									
3. Amit Bandyopadhyay and Susmita Bose, Additive Manufacturing, CRC Press.									
4. Chua C. K., Fundamentals of Additive Manufacturing and 3D Printing, World Scientific Publishing.									

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Reference Books:

1. Milan Brandt, Laser Additive Manufacturing: Materials, Design, Technologies, and Applications, Woodhead Publishing.
2. B. V. V. S. Prasad, Additive Manufacturing Processes, McGraw Hill Education.
3. Christopher Barnatt, 3D Printing: The Next Industrial Revolution, ExplainingTheFuture.com.
4. D. T. Pham and S. S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer
5. Sabrie Soloman, 3D Printing and Design, Khanna Book Publishing Company, New Delhi

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Machine Learning for Robotics							Code: RAPE604B		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites:									
Linear Algebra, Multivariate Calculus, Probability & Statistics, Kinematics and Dynamics, and Python.									
Course Objectives:									
1. Understand fundamental mathematical formulations and data pre-processing techniques required for robotic sensor systems. 2. Explain supervised learning algorithms used for prediction and classification tasks in robotics. 3. Illustrate unsupervised learning and spatial clustering models for grouping unstructured sensor data. 4. Implement deep learning and vision-based architectures for object recognition and robotic perception. 5. Analyze reinforcement learning framework strategies for autonomous motion planning and manipulation. 6. Evaluate edge AI deployment models and optimization strategies for real-time performance on embedded robotic platforms.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain core mathematical concepts and data preprocessing workflows used in sensor data analysis.								
CO2	Apply supervised learning algorithms (regression and classification) to solve predictive and decision-making problems in robotic systems.								
CO3	Analyze spatial clustering and unsupervised learning techniques for grouping and segmenting unstructured robotic sensor data.								
CO4	Implement deep learning and Convolutional Neural Network (CNN) architectures for visual object recognition and robot perception tasks.								
CO5	Evaluate reinforcement learning frameworks and reward mechanisms for autonomous motion planning, obstacle avoidance, and manipulation.								
CO6	Deploy optimized Edge AI models onto embedded hardware platforms for real-time robotic inference and action.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Foundations of ML & Statistical Data Processing for Robotics: Introduction: What is Machine Learning and why is it useful in robotics Python Tools: Basics of NumPy, Pandas, and Scikit-Learn for handling data. Sensor Data: Spatial data processing, handling noisy sensor logs, data wrangling, normalization, and sensor calibration								06
2.	Supervised in Robotic Kinematics: Regression models: Linear, Polynomial, and Ridge regression for Inverse Kinematics approximations and actuator mapping. Classification: Support Vector Machines (SVM), Decision Trees, and Random Forests for fault detection, anomaly detection, and terrain classification. Clustering: K-Means for spatial grouping.								06

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3.	Unsupervised Learning & Spatial Clustering in Robotics: Introduction to unsupervised learning paradigms. Spatial grouping algorithms: K-Means clustering, Hierarchical clustering, and Density-Based Spatial Clustering of Applications with Noise (DBSCAN).	07
4.	Deep Learning & Robot Perception (Computer Vision): Neural Network foundations: Multi-Layer Perceptrons (MLPs), backpropagation, optimization functions (Adam, SGD). Convolutional Neural Networks (CNNs) for vision-based picking, object detection, bounding box estimation, and semantic scene segmentation using PyTorch / TensorFlow.	06
5.	Reinforcement Learning (RL) for Motion Planning & Manipulation: Markov Decision Processes (MDP), Q-Learning, Temporal Difference learning. Deep Q-Networks (DQN) and Policy Gradient methods. Application of RL in path planning, obstacle avoidance, robotic arm manipulation	07
6.	Edge AI Deployment & Real-time Robotics: Model optimization strategies: Quantization, pruning, and hardware acceleration. Deploying intelligence onto edge compute devices (NVIDIA Jetson Nano, Raspberry Pi, and microcontrollers). Case studies: Smart sorting conveyors, autonomous line/wall followers, and AGVs.	07
TOTAL		39

Text Books:

1. Siegwart, R., Nourbakhsh, I. R., and Scaramuzza, D., 'Introduction to Autonomous Mobile Robots', MIT Press, 2011.
2. Sutton, R. S., and Barto, A. G., 'Reinforcement Learning: An Introduction', MIT Press, 2018.
3. Bishop, C. M., 'Pattern Recognition and Machine Learning', Springer, 2006.

Reference Books:

1. Thrun, S., Burgard, W., and Fox, D., 'Probabilistic Robotics', MIT Press, 2005.
2. Corke, P., 'Robotics, Vision and Control: Fundamental Algorithms in MATLAB', Springer, 2017.
3. Goodfellow, I., Bengio, Y., and Courville, A., 'Deep Learning', MIT Press, 2016.

E-Resources:

1. NPTEL Course: 'Robotics' - IIT Bombay / IIT IISc / IIT Kharagpur
<http://nptel.ac.in/courses/112101099>
2. NPTEL Course: 'Introduction to Machine Learning' - IIT Madras
<http://nptel.ac.in/courses/106106139>
3. ROS Wiki & Tutorials
<http://docs.ros.org>
4. OpenAI Gym Documentation & Baseline Robotic Environments
<http://gymnasium.farama.org>

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Machine Learning for Robotics Lab							Code: RAPE604BP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
	02	-	01			-	25	-	25
Prerequisites:									
Linear Algebra, Multivariate Calculus, Probability & Statistics, Basics of Kinematics and Dynamics, and Python Programming.									
Course Objectives:									
1. Process robotic sensor data and apply machine learning for motion prediction and fault detection. 2. Apply clustering, deep learning, and reinforcement learning for robotic perception and navigation. 3. Develop basic ROS nodes for sensor data communication and robotic applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Clean robotic sensor datasets and predict motor/kinematic angles using regression models.								
CO2	Build models to diagnose motor faults and cluster 2D LiDAR data for map-based grouping.								
CO3	Implement CNNs for vision-based object detection and Q-Learning for autonomous 2D navigation.								
CO4	Integrate trained ML models into ROS nodes and deploy lightweight models onto edge devices.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Robotic Sensor Data Cleaning and Filtering: Clean and filter noisy robotic sensor data using Python (NumPy & Pandas).							02	
2.	Kinematic Angle & Motion Prediction: Build a simple Linear Regression model to predict motor angles/robot arm positions.							04	
3.	Actuator Fault Detection: Create a simple Decision Tree or SVM classifier to detect motor or sensor faults.							02	
4.	Obstacle & Map Data Grouping: Apply K-Means clustering to group nearby obstacle points from 2D LiDAR or map data.							04	
5.	Object Identification with Deep Learning: Train a simple CNN in PyTorch/Tensor Flow to identify objects in camera images.							04	
6.	2D Navigation & Obstacle Avoidance: Implement basic Q-Learning to help a simple 2D virtual robot navigate around obstacles.							04	
7.	Basic ROS Workspace & Node Setup: Set up a basic ROS workspace and practice passing sensor data between nodes.							04	
8.	Vision-Guided Robot Navigation: Connect a pre-trained ML object detection model to a ROS node to guide robot movement.							04	
9.	Edge AI Model Deployment: Convert and run a pre-trained ML model on a single-board computer (Raspberry Pi or Jetson Nano).							02	
TOTAL							26		

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Reference Books:	
1. Thrun, S., Burgard, W., and Fox, D., 'Probabilistic Robotics', MIT Press, 2005. 2. Corke, P., 'Robotics, Vision and Control: Fundamental Algorithms in MATLAB', Springer, 2017. 3. Goodfellow, I., Bengio, Y., and Courville, A., 'Deep Learning', MIT Press, 2016	
E-Resources:	
1. Practical Programming https://youtu.be/iqBUpA7fg5E?si=h14DmTOi_IUg7CBy 2. ABB Robotics Library https://search.abb.com/library?utm_source=chatgpt.com	

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Computational Techniques in Robotics							Code: RAPE604C		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Fundamentals of Numerical Methods and Engineering Mathematics.									
Course Objectives:									
1.Describe Lagrangian, Eulerian, weighted residual, potential energy, and control volume modeling approaches. 2.Discuss problem domains, discretization, numerical grids, grid structures, generation techniques, and Jacobians. 3.Apply finite element methods to analyze stresses and compute structural mechanics problem. 4.Solve second order partial differential equations and heat conduction problems using finite difference methods. 5.Assess computational fluid dynamics governing equations, boundary conditions, and diffusion problems. 6.Create pressure velocity coupling algorithms and turbulence models for fluid flows.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Remember Lagrangian, Eulerian, weighted residual, potential energy, and control volume methods for mathematical modeling.								
CO2	Understand problem domains, discretization, geometry, numerical grids, grid structures, generation techniques, and computing the Jacobian matrix.								
CO3	Calculate stresses, strains, and temperature effects for bar problems using finite element and classical solution methods.								
CO4	Analyze differential equation classifications, finite difference formulations, consistency analysis, and stability for various unsteady heat conduction problems.								
CO5	Evaluate integral formulations, governing equations of computational fluid dynamics, boundary conditions, and steady state diffusion problems.								
CO6	Design solution algorithms for pressure velocity coupling, turbulent flow transitions, RANS equations, and advanced computational simulation models.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Introduction to Numerical/Computational Investigations: Characterization, mathematical modeling, Lagrangian and Euler description of the properties of material points, Weighted Residual and Potential Energy Approach (Lagrangian), Control Volume Formulation (Eulerian).							06	
2.	Discretization: Problem Domain, Essence of Discretization, Geometry, Numerical Grids, Grid Types, Grid Structure, Structured and Unstructured Grid Generation, Jacobian.							06	
3.	Finite Element Method: Steps involved in FEA, FEM Vs Classical Methods, Stresses and Strains in a typical Element, Strain-Displacement and Stress Strain Relations, Plane stress and plane strain conditions, Temperature Effects (No derivations), Rayleigh-Ritz Method, Galerkin’s Method, Modeling of 1-D bar problem, Problem on stepped bar, Stiffness matrix.							07	

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4.	Second-Order PDEs: Classification of Elliptic, Parabolic and Hyperbolic, Initial and Boundary Conditions. Finite Difference Formulations: Taylor Series Expansion, Forward and Backward differencing of order (Δx) and central differencing of order (Δx^2), 1-D unsteady heat conduction equation, Consistency Analysis, Von Neumann Stability Analysis. Explicit and Implicit Formulations.	06
5.	Finite Volume Method: Introduction to Integral Formulation, Governing equations of CFD, Continuity equation, Momentum equation, Energy equation, Conservative and non-conservative form. Initial and boundary conditions – Dirichlet, Neumann, Mixed or Robin. 1-D Steady-state Diffusion problem.	07
6.	Pressure-Velocity Coupling and Turbulence Models: Solution algorithms for Pressure Velocity coupling in steady state flow, SIMPLE, SIMPLE-R, and PISO, Introduction to Turbulence, Transition From laminar turbulent flow, Characteristics of simple turbulent flow, RANS, classical turbulence models, Introduction to LES and DNS.	07
TOTAL		39
Text Books:		
1. Hoffmann, K. A. and Chiang, S. T., Computational Fluid Dynamics for Engineers: Engineering Education System, Kansas, USA, Fourth Edition, 2000. 2. Chapra, S. C., and Canale, R. P., Numerical Methods for Engineers, 7th ed., McGraw-Hill Education India Pvt. Ltd. 2016. 3. Anderson, J.D. (Jr), Computational Fluid Dynamics: the Basics with Applications, Book Company, McGraw-Hill. Indian Edition. 2017.		
Reference Books:		
1. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, CRC Press, 4th Edition 2020. 2. Tirupathi, R. C, Belegundu, A. D., Introduction to Finite Elements in Engineering, Pearson Education India, 3rd Edition, 2015.		
E-Resources:		
1. Numerical Methods for Engineers (IIT Madras): https://nptel.ac.in/courses/127106019 2. Numerical Methods / Analysis (IIT Roorkee / SWAYAM): https://onlinecourses.nptel.ac.in/noc24_ma54/preview 3. Stanford Online / Academic Portal: https://stanford.edu		

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: V		
Course: Computational Techniques in Robotics Lab							Code: RAPE604CP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Fundamentals of Numerical Methods and Engineering Mathematics									
Course Objectives:									
1. Apply fundamental numerical methods, including Lagrangian-Eulerian descriptions and finite element formulations, to model practical engineering and physical problems									
2. Analyze partial differential equations, finite difference schemes, stability criteria, and conservation laws governing fluid and structural mechanics.									
3. Evaluate the accuracy, efficiency, and performance of numerical algorithms, pressure-velocity coupling schemes, and turbulence models in computational fluid dynamics.									
4. Create comprehensive computational simulation models and discretization frameworks for complex engineering systems.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Apply finite element and finite difference techniques to solve 1-D engineering problems and construct structured or unstructured numerical grids								
CO2	Analyze the physical behavior, classification, consistency, and stability of differential equations and fluid flow governing equations.								
CO3	Evaluate advanced solver algorithms (such as SIMPLE and PISO) and various turbulence models for internal and external flow simulations								
CO4	Create integrated numerical models and computational solutions for fluid flow, heat transfer, and mechanics applications.								
List of Experiments:									
Exp. No	Description								Duration (Hrs.)
All are compulsory									
1.	Fundamentals of Computational Mechanics: Lagrangian and Eulerian Approaches								02
2.	Applications of Partial Differential Equations and Boundary Conditions								02
3.	Analysis of CFD Governing Equations and Integral Formulation								04
4.	Fundamentals of Grid Generation and Spatial Discretization								02
5.	Fundamentals of the Finite Element Method and 1-D Analysis								04
6.	Finite Difference Methods and Stability Analysis								04
7.	Numerical Solution of a 1-D Steady-State Diffusion Problem with Source Term using the Finite Volume Method (FVM)								04
8.	CFD Simulation of 2D Turbulent Flow Over a Backward-Facing Step Using the SIMPLE Algorithm and RANS Turbulence Models								04
9.	Pressure-Velocity Coupling and Turbulence Modeling in CFD								
TOTAL								26	

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Reference Books:

1. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, CRC Press, 4th Edition 2020.
2. Tirupathi, R. C, Belegundu, A. D., Introduction to Finite Elements in Engineering, Pearson Education India, 3rd Edition, 2015.

E-Learning:

1. Computational Methods in Robotics virtual Lab
<https://mr-iitkgp.vlabs.ac.in/exp/kgp/theory.html>

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PROGRAM ELECTIVE – III

**(Select any one course from the given Open
Elective Courses)**

DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Industrial Robotics and Material Handling Systems							Code: RAPE605A		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	40	60	-	-	-	100
Prerequisites:									
Engineering Mechanics, Manufacturing and Production system, Basic Concepts of Sensor ,Actuators, Control System.									
Course Objectives:									
1. To identify the fundamentals, components, classifications, and terminology of industrial robots and material handling systems. 2. To explain the principles of robot kinematics, sensors, actuators, controllers, and programming techniques used in industrial automation. 3. To demonstrate the use of material handling equipment such as conveyors, cranes, automated guided vehicles (AGVs), and automated storage systems in manufacturing applications. 4. To analyse the applications and performance of robotics and automated material handling systems in flexible manufacturing and smart production environments. 5. To evaluate industrial automation tools, safety standards, and simulation software for robotics and material handling operations based on industrial requirements. 6. To judging and recommendation suitable robotic and material handling systems for real-world industrial applications with advance applications of robotics.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Understand basic concepts of fundamental of robotics their parts of and types.								
CO2	Understand automatic manufacturing cells with robotic control using the principle behind robotic drive system, end effectors, sensor.								
CO3	Explain different storage system and Data computing used in industry.								
CO4	Analyze of end effectors of robots for industrial applications.								
CO5	Develop the knowledge for material handling and ASRS system.								
CO6	Apply fundamental Concepts of Robotics for Problem solving and advanced application								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Introduction to Industrial robot and MM: Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell.							04	
2.	Robots For Inspection : Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.							04	
3.	Storage and Data capturing systems : Conventional storage methods and equipment’s Storage system performance, Analysis of Automated storage/retrieval systems (ASRS) and Carousel Storage system. Automatic data capturing system (ADC), Bar coding, Radio frequency identification (RFID), Optical character recognition, Magnetic stripes							04	

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4.	End Effectors: Gripper force analysis and gripper design, design of multiple, degrees of freedom, active and passive grippers. Selection Of Robot: Factors influencing the choice of a robot, robot performance testing, economics of robotisation, Impact of robot on industry and society Gripper force analysis and gripper design, design of multiple degrees of freedom, active and passive grippers.	05
5.	Material Handling: Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems(ASRS), bar code technology, radio frequency identification technology.	05
6.	Advanced Applications of Robots : Military and medical applications, robot for underwater applications Robots, Climbing Robots, Machine mounted Robots. Interfacing Robots with computers. Obstacle Avoidance: Lee's Algorithm; Counter Path Defining using 'via' point, blending	04
TOTAL		26
Text Books:		
- Groover M.P., Weiss M., Nagel R.N., Odrey N.G., "Industrial Robotics Technology - Programming and Applications", McGraw Hill Book Co. - Fu K.S., Gonzalez R.C., Lee C.S.G., "Robotics Control Sensing, Vision and intelligence", McGraw Hill Book Co - Hartenberg and Denavit, "Kinematics and Synthesis of Linkages", McGraw Hill Book Co. - Hirchhorn J., "Kinematics and Dynamics of Machinery", McGraw Hill Book Co. - Todd D.J., "Fundamentals of Robot Technology", Wiley Publications - Paul R., "Robots - Manipulators, Mathematics, Programming and Control", MIT Press. - Jacob Fruchlboum, "Bulk Material Handling Handbook", 1st Edition, Springer, 1988 - Monkman, G. J.; Hesse, S.; Steinmann, R.; Schunk, H, " Robot Gripper" Wiley-VCH. p. 62. ISBN 978-3-527-40619-7		
Reference Books:		
- Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, "Robotic Engineering – An integrated Approach" Prentice HallIndia, New Delhi, 2001. - Mikell P. Groover,"Automation, Production Systems, and Computer Integrated Manufacturing",2nd Edition, John Wiley & sons, Inc, 2007 - James A Rehg, "Introduction to Robotics in CIM Systems", Prentice Hall of India, 2002. - Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994.		

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E-Resources:

1. Industrial Robotics: Theories for Implementation by Dr. Arun Dayal Udai
<https://youtu.be/HdSVjhfGquM?si=fpBpdm2HltmfBRoH> _
2. Robot Grippers: Classification, Design and Selection
<https://youtu.be/mQvT4Z0i3OA?si=UkZNiPC4GrKMm-rz>
3. Material Handling system by AB Classes https://youtu.be/FUV-Bk8OiO8?si=_I9flna2LUUsFeJQD
4. Industrial Robots: Introduction, Anatomy, Degree of freedom, applications, Sensors, Drives, Grippers https://youtu.be/QiFbrmJTib4?si=_vrErFOCz25DH3wM
5. Advance application of robotics: <https://youtu.be/5buEG8B5Mm4?si=Ag9sbD3Y0fGGi7jX>
6. Material Handling system : https://youtu.be/Up1oSSJn6oM?si=kyau5bGfnMC_r2M

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Industrial Robotics and Material Handling Systems Lab							Code: RAPE605AP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Engineering Mechanics, Manufacturing and Production system, Basic Concepts of Sensor ,Actuators, Control System									
Course Objectives:									
1. To analyze robot performance and end-effector functions.									
2. To study robotic applications in manufacturing and material handling.									
3. To understand advanced industrial robotics through practical case study.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	To understand the applications of industrial robots in various fields.								
CO2	To evaluate robot performance and end-effector functions.								
CO3	To study robotic applications in manufacturing and material handling.								
Course Contents:									
Exp. No.	Description							Duration (Hrs.)	
Any Eight Experiments from list given below:									
1.	To Study of robot application in various fields of industry.							02	
2.	To demonstrate numerical based on visual inspection.							02	
3.	To demonstrate numerical based on performance testing of robot.							02	
4.	To demonstrate Numerical based on end effectors analysis.							02	
5.	To Study about application of robots in manufacturing units.							02	
6.	To Study about material handling techniques							02	
7.	To Study of pick and place industrial robot							02	
8.	To Study of configuration of robots and motion of robot manipulator							04	
9.	To study Storage techniques: Bar code technology.							04	
10.	Case Study on Advanced industrial application of robots							04	
TOTAL							26		
Reference Books:									
1. Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, “Robotic Engineering – An integrated Approach” Prentice HallIndia, New Delhi, 2001.									
2. Mikell P. Groover,”Automation, Production Systems, and Computer Integrated Manufacturing“,2nd Edition, John Wiley & sons, Inc, 2007									
3. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994.									
E-Resources:									
1. Robot Grippers: Classification, Design and Selection https://youtu.be/mQvT4Z0i3OA?si=UkZNIpC4GrKMm-rz									
2. Material Handling system by AB Classes https://youtu.be/FUV-Bk8OiO8?si=_I9flna2LUUsFeJOD									

DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Internet of Robotic Things							Code: RAPE605B		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	40	60	-	-	-	100
Prerequisites:									
Basic Electronics and Electrical Engineering, Programming Fundamentals									
Course Objectives:									
1. To understand the fundamental concepts of IoT, robotics, automation, and Industry 4.0 technologies used in smart robotic systems.									
2. To Illustrate knowledge of embedded controllers, sensor interfacing techniques, and actuator control for robotic applications									
3. To recommend various wired and wireless communication protocols used in IoT-enabled robotic systems and industrial automation.									
4. To analyze cloud computing platforms, data analytics and real-time monitoring techniques for IoT-based robotics applications.									
5. To evaluate ROS, autonomous navigation, computer vision, and AI in intelligent robotics.									
6. To develop IoT and robotics to industrial automation and smart manufacturing through projects.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Understand IoT fundamentals and robotic systems.								
CO2	Interface sensors and actuators with robotic platforms.								
CO3	Implement suitable communication protocols and networking technologies.								
CO4	Demonstrate IoT-based monitoring systems using cloud platforms.								
CO5	Design robotic applications ROS for robotic control.								
CO6	Develop IoT-enabled robotic solutions for real-world problems.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Fundamentals of IoT and Robotics: Introduction to IoT, Characteristics and Applications of IoT, Basics of Robotics and Automation, Components of Robotic Systems, IoT Architecture for Robotics, Sensors and Actuators in Robotics, Embedded Systems for Robotics, Industry 4.0 and Smart Robotics								07
2.	Embedded Controllers and Sensor Interfacing: Microcontrollers: Arduino, ESP32, STM32, Pi for Robotics, Interfacing Sensors: Ultrasonic, IR, IMU, Temperature, Vision Sensors, Motor Drivers and Servo Control, ADC/DAC Concepts, Real-Time Data Acquisition, Signal Conditioning								06
3.	Communication Protocols and Wireless Networks: Wired vs Wireless Communication, Wi-Fi, Bluetooth, ZigBee, LoRa, RFID, MQTT, HTTP, CoAP Protocols, IoT Communication Architecture, Cloud Connectivity, Edge and Fog Computing, Data Transmission in Robotics								06

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4.	IoT Cloud and Robotics Data Analytics Cloud Platforms for IoT, AWS IoT, Azure IoT Basics, Data Collection and Monitoring, Dashboard Development, Real-Time Data Visualization, Data Logging and Remote Access, Basics of AI and Machine Learning in Robotics	07
5.	Robotics Operating System and Intelligent Robotics Introduction to ROS, Robot Localization and Navigation, Mobile Robot Control, Autonomous Robotic Systems, Computer Vision Basics, AI in Robotics, Edge AI and Smart Decision Systems	06
6.	Industrial IoT and Applications in Robotics Industrial IoT (IIoT), Smart Manufacturing Systems, PLC/SCADA Integration, Smart Warehouse Robots, Agricultural and Medical Robots, Drone IoT Systems, Cybersecurity in IoT Robotics, Case Studies and Mini Project	07
TOTAL		39

Text Books:

- Greengard, Samuel. The internet of things. MIT press, 2021.
- Chaouchi, Hakima, ed. The internet of things: Connecting objects to the web. John Wiley & Sons, 2013.
- Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", Wiley Publications, 2nd Edition, 2018. ISBN: 9781119545264
- Arshdeep Bahga and Vijay Madisetti, Internet of Things: A Hands-on Approach, Universities Press, 1st Edition, 2015. ISBN: 978-8173719547

Reference Books:

- Kamal, R. "Internet of Things – Architecture and Design Principles" 1st Edition, Mcgraw Hill, 2017.
- Simone Cirani, "Internet of Things- Architectures, Protocols and Standards", WILEY, 2018.
- Qusay F. Hassan, "Internet of Things A to Z: Technologies and Applications", Wiley-IEEE Press, 2018.
- Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press, 2017. ISBN: 978-1498778510

E-Resources:

- Introduction to Industry 4.0 and Industrial Internet of Things – <https://nptel.ac.in/courses/106105195?>
- Raspberry Pi Documentation – <https://www.raspberrypi.com/documentation/>
- Hive MQTT Essentials – <https://www.hivemq.com/mqtt-essentials/>
- Thing Speak IoT Analytics Platform – <https://thingspeak.com/>
- Siemens Industrial Edge & IIoT – <https://www.siemens.com/industrial-edge>

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Internet of Robotic Things Lab							Code: RAPE605BP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Basic Electronics and Electrical Engineering, Programming Fundamentals									
Course Objectives:									
1. To study the interfacing and real-time data acquisition of sensors and actuators wit Arduino/ESP32.									
2. To implement wireless, MQTT, and cloud communication for remote monitoring and control of robotic systems.									
3. To develop an intelligent IoT-based robotic system integrating sensing, motor control, communication, and computer vision.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Develop and control IoT-enabled robotic systems using Arduino/ESP32, sensors, motors, and motor drivers.								
CO2	Implement wireless, MQTT, and cloud-based communication for real-time robotic monitoring and control.								
CO3	Design intelligent robotic applications using obstacle avoidance, computer vision, and IoT dashboards.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Study and implementation of an IoT-based robotic system architecture using Arduino/ESP32 and sensors.							02	
2.	Study of Interfacing Ultrasonic, IR, Temperature, and IMU sensors with Arduino/ESP32 for real-time data acquisition and monitoring.							02	
3.	Study of Servo Motor and DC Motor Control Using Motor Drivers for Robotic Movement and Automation Applications.							02	
4.	Design and Development of an Obstacle Detection and Avoidance Robot Using Ultrasonic and IR Sensors.							02	
5.	Execute wireless communication between robotic devices using Wi-Fi/Bluetooth and monitor data transmission.							02	
6.	Build MQTT-based communication between ESP32 and cloud platform for remote robotic monitoring and control.							02	
7.	Develop an IoT dashboard using AWS IoT/Azure IoT/ThingSpeak for real-time visualization and data logging of robotic sensor data.							04	
8.	Compute vision-based object detection and tracking using OpenCV integrated with a robotic platform.							04	
9.	Mini Project: Development of an IoT-enabled intelligent robotic system (Smart Warehouse Robot, Agricultural Robot, Smart Surveillance Robot, or IIoT Monitoring System).							06	
TOTAL							26		

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Reference Books:

1. Kamal, R., "Internet of Things – Architecture and Design Principles," 1st Edition, Mcgraw Hill, 2017.
2. Simone Cirani, "Internet of Things- Architectures, Protocols and Standards", WILEY, 2018.
3. Qusay F. Hassan, "Internet of Things A to Z: Technologies and Applications", Wiley-IEEE Press, 2018.
4. Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press, 2017. ISBN: 978-1498778510

E-Resources:

1. Introduction to Industry 4.0 and Industrial Internet of Things –
<https://nptel.ac.in/courses/106105195?>
2. Raspberry Pi Documentation
<https://www.raspberrypi.com/documentation/>
3. Hive MQTT Essentials
<https://www.hivemq.com/mqtt-essentials/>
4. Thing Speak IoT Analytics Platform
<https://thingspeak.com/>
5. Siemens Industrial Edge & IIoT
<https://www.siemens.com/industrial-edge>
6. Azure Internet of Things operations Edge based and Cloud based
<https://learn.microsoft.com/azure/iot-fundamentals/>

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Mobile and Autonomous Robots							Code: RAPE605C		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	40	60	-	-	-	100
Prerequisites:									
Robotics Kinematics and Dynamics and Hydraulics and Pneumatics.									
Course Objectives:									
1.Remember the fundamental classes, kinematic models, and sensing technologies of autonomous vehicles.									
2.Explain reference frames, rotational matrices, and UAV kinematics describing geometric motion without forces.									
3.Apply aeromechanics, propulsion, flight control, and path planning principles to UAV systems.									
4.Analyze aircraft geometry configurations, kinematic dynamics, modeling, and propeller theory for drones.									
5.Evaluate underwater vehicle systems, including actuation, sensing, communication, manipulation, interaction, and guidance methods.									
6.Design optimal path planning algorithms, motion control methods, and trajectory stability systems.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Identify autonomous vehicle classes, terminology, kinematic models, and core sensing technologies.								
CO2	Describe reference frames, rotational matrices, and UAV kinematics detailing the geometric motion of aircraft without forces and torques.								
CO3	Illustrate UAV aeromechanics, atmospheric properties, aerodynamics, propulsion, perception, state estimation, flight control systems, and path planning methods.								
CO4	Solve complex engineering problems involving aircraft geometry configurations, drone kinematics, dynamics modeling, transformations, and propeller theory operations.								
CO5	Estimate operational capabilities of underwater gliders, autonomous vehicles, remote systems, actuation, sensing, communication, manipulation, interaction, and guidance systems.								
CO6	Develop collision free path planning algorithms, obstacle avoidance, kinematic control, dynamic control, and trajectory stability.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to UAV: Introduction to autonomous robotics, Classes and Missions of UAVs, Definitions and Terminology, Discussion on different types of unmanned vehicles: ground (wheeled and legged), aerial (fixed, flapping, and rotary wings), underwater vehicles mobile robot kinematic models- need and applications of autonomous mobile robots. Sensing technologies for perception in autonomous systems.								07

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2.	Frames: Reference frames, Coordinate systems (such as inertial/earth-fixed and body-fixed frames), Rotational matrices specifically representing (orientation or attitude roll, pitch, yaw) of the UAV. UAV-kinematics. geometric motion of the aircraft (linear and angular velocities to its position and orientation), without considering the forces and torques causing the motion.	07
3.	Aeromechanics and structures: Forces acting on UAV, Physical properties and structure of the atmosphere, Aerodynamics, Angle of attack, Mach number, Lift and Drag, Propulsion and airplane structures, Aerial Robot Loop.	06
4.	Unmanned-Aircraft Geometry and Configurations, Aircraft Geometry Relationships, Wing System Configurations, Tail Configurations, Fuselage System Configurations, Rotorcraft Configurations. Fixed Wing and Multirotor Drones: Introduction-Kinematic and dynamics modelling formulation of drones, Transformation and representations, Dynamics of a fixed-wing drones, Propeller theory-Thrust and drag moment.	07
5.	Introduction to autonomous underwater glider (AUGs), autonomous underwater vehicles (AUVs), and remotely operated underwater vehicles. Actuation and sensing systems; communication; manipulation; interaction and guidance.	06
6.	Motion path planning, control and stability: path planning algorithms - collision-free path planning - sensor-based obstacle avoidance - motion control methods: kinematic control, dynamic control, controllability and stability about a point and trajectory.	06
TOTAL		39

Text Books:

1. Beard, R. W. and McLain, T. M., Small Unmanned Aircraft: Theory and Practice, Princeton University Press first edition, 2012.
2. Reg, A., Unmanned Aircraft Systems UAV design, development and deployment, John Wiley & Sons, Ltd April 2010.
3. John, M. H., Designing Autonomous Mobile Robots, Elsevier, 2004.

Reference Books:

1. Do, K. D., and Pan, J., Control of ships and Underwater Vehicles: Design for underactuated and Non-linear Marine Systems, Advances in Industrial Control, 1edition, Springer, 2009.
2. Griffiths, G., Technology and Applications of Autonomous Underwater Vehicles, Ocean science and technology, vol. 2, Taylor & Francis / CRC Press (London / Abingdon), 2002.
3. Newman, J. N. "Marine Hydrodynamics", MIT Press, USA. 1997.

E-Resources:

TU Munich: Autonomous Navigation for Flying Robots <https://cvg.cit.tum.de/teaching/online/visnavfly->

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Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Mobile and Autonomous Robots Lab							Code: RAPE605CP		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites:									
Hydraulics and Pneumatics.									
Course Objectives:									
1. Students will demonstrate numerical root finding, UAV kinematics, aerodynamics, configurations, and autonomous navigation techniques.									
2. Students will examine errors, coordinate transformations, aerodynamic forces, structural parameters, and vehicle dynamics models.									
3. Students will evaluate system performance, underwater control loops, and sensor based path planning strategies.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Learners successfully apply computational routines, kinematic transformations, aerodynamic simulations, and autonomous navigation algorithm implementations.								
CO2	Students thoroughly analyze truncation errors, rotation matrices, lift forces, design parameters, and longitudinal dynamics.								
CO3	Learners critically validate UAV configurations, pressure feedback control loops, and reactive collision avoidance planning.								
List of Experiments:									
Exp. No	Description								Duration (Hrs.)
1.	Implementation and Error Analysis of the Newton-Raphson Method for Root-Finding of Non-Linear Equations.								02
2.	Simulation of UAV Kinematics and Coordinate Transformations Using Rotation Matrices (Roll, Pitch, Yaw).								04
3.	Simulation of Aerodynamic Forces (Lift and Drag) and Atmospheric Effects Across Varying Angles of Attack for a UAV								04
4.	Geometric Design and Parameter Analysis of Fixed-Wing and Rotorcraft UAV Configurations.								04
5.	Dynamic Simulation of Fixed-Wing UAV Longitudinal Motion Coupled with Propeller Thrust and Drag Moment Theory.								04
6.	Simulation of an AUV Depth Guidance and Actuation Control Loop Using Pressure Sensor Feedback.								04
7.	Implementation of Kinematic Motion Control and Sensor-Based Obstacle Avoidance Path Planning for an Autonomous Vehicle.								04
Total								26	

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Text Books:
1. Beard, R. W. and McLain, T. M., Small Unmanned Aircraft: Theory and Practice, Princeton University Press first edition, 2012. 2. Reg, A., Unmanned Aircraft Systems UAV design, development and deployment, John Wiley & Sons, Ltd April 2010. 3. John, M. H., Designing Autonomous Mobile Robots, Elsevier, 2004.
Reference Books:
1. Do, K. D., and Pan, J., Control of ships and Underwater Vehicles: Design for underactuated and Non-linear Marine Systems, Advances in Industrial Control, 1edition, Springer, 2009. 2. Griffiths, G., Technology and Applications of Autonomous Underwater Vehicles, Ocean science and technology, vol. 2, Taylor & Francis / CRC Press (London / Abingdon), 2002. 3. Newman, J. N. “Marine Hydrodynamics”, MIT Press, USA. 1997.
E-Resources:
1. NPTEL: Design of Fixed Wing Unmanned Aerial Vehicles: <u>NPTEL Fixed Wing UAV Design Course</u>

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Robot Control System							Code: RAMD604		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites:									
Basic knowledge of Control Systems, Engineering Mathematics, Mechanics, and Programming Fundamentals, Robot Kinematics and Dynamics									
Course Objectives:									
1. To understand the fundamentals of robotic systems and coordinate transformations. 2. To analyze robot kinematics and dynamics for manipulator control. 3. To study actuators and feedback control techniques used in robotics. 4. To apply motion planning and sensor integration methods in robotic systems. 5. To understand intelligent and autonomous robot control strategies. 6. To develop problem-solving skills for real-world robotic applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the fundamentals of robotic systems, coordinate transformations, and robot configurations.								
CO2	Apply kinematic principles to analyze the position, velocity, and workspace of robotic manipulators.								
CO3	Develop dynamic models of robotic manipulators and understand actuator characteristics.								
CO4	Design feedback control systems for robotic motion and trajectory tracking.								
CO5	Apply sensor integration and motion planning techniques in robot control applications.								
CO6	Evaluate advanced robotic control approaches including intelligent and autonomous control methods.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Introduction to Robotics and Control Systems- Introduction to robotics, control systems, Open-loop and closed-loop control systems, Manual vs automatic control, Types of control systems, Classification of robots, Components of robotic systems, Robot configurations and coordinate systems, Degrees of freedom (DOF), Robot programming basics, Industrial applications of robots.							06	
2.	Robot Kinematics- Mathematical modeling basics, Differential equations of physical systems, Forward kinematics, Inverse kinematics, Denavit–Hartenberg (D-H) convention, Velocity kinematics, Jacobian matrix, Singularities and workspace analysis							06	
3.	Robot Dynamics and Actuation- Dynamic modeling of robots, Newton–Euler formulation, Lagrangian formulation, Trajectory generation, Actuators: DC motors, servo motors, stepper motors, Electrical systems modeling , hydraulic and pneumatic actuators, Power transmission systems							07	

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4.	Robot Control Techniques- Open-loop and closed-loop control, PID control for robots, Joint space control, Cartesian space control, Stability analysis, Adaptive and robust control basics, Time response analysis , Stability concept , Routh-Hurwitz stability criterion, Digital control implementation, Frequency response fundamentals	07
5.	Sensors, Vision, and Motion Planning- Position and velocity sensors, Force and torque sensors, Machine vision systems, Sensor integration, Path planning, Obstacle avoidance, Mobile robot navigation basics , Motion control systems, Trajectory planning and tracking , Controllability and observability	06
6.	Intelligent and Autonomous Robot Control- Artificial intelligence in robotics, Fuzzy logic control, Neural network control, Machine learning applications, Autonomous robots, Human–robot interaction, Collaborative robots (Cobots), Recent trends in robotics , Digital control systems, Autonomous navigation basics, Industrial robot control architecture, Robot kinematics and control integration.	07
TOTAL		39
Text Books:		
1. Robotics: Modelling, Planning and Control — Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo. 2. Introduction to Robotics: Mechanics and Control — John J. Craig. 3. Robot Modeling and Control — Mark W. Spong, Seth Hutchinson, M. Vidyasagar. 4. Modern Robotics — Kevin M. Lynch and Frank C. Park. 5. Industrial Robotics — Mikell P. Groover.		
Reference Books:		
1. Robotics and Control, by R K. Mittle, I J. Nagrath, Tata Mc Graw Hill. 2. Control Systems Engineering by Norman S. Nise , Pearsons. 3. Robot Manipulator Control, Theory and Practice – Frank Lewis, Darren Dawson. 4. Robotic Control by P. M. Taylor , Springer.		
E-Resources:		
1. https://nptel.ac.in/courses/107106081; Control Systems, IIT Madras 2. https://nptel.ac.in/courses/108103863; Control Engineering for Robotics, IIT Guwahati 3. https://nptel.ac.in/courses/112107289; Robotics and Control: Theory and Practice , IIT Roorke		

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Program: B. Tech. (Robotics & Automation)							Semester: VI		
Course: Robot Control System Lab							Code: RAMD604P		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	25	-	25
Basic knowledge of Control Systems, Engineering Mathematics, Mechanics, and Programming Fundamentals, Robot Kinematics and Dynamics									
Course Objectives:									
1. To understand and model robotic control systems using MATLAB/Simulink.									
2. To analyze and implement robot kinematics, workspace, and trajectory generation.									
3. To develop and simulate robotic path planning, control, and obstacle avoidance.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Model and analyze robotic control systems using MATLAB/Simulink.								
CO2	Apply kinematic transformations, D-H parameters, and inverse kinematics to robotic manipulators.								
CO3	Design and simulate robot trajectories, path planning, and obstacle avoidance using MATLAB Robotics System Toolbox.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	To model and analyze the response of open-loop and closed-loop control systems using MATLAB.							02	
2.	To perform coordinate transformations (translation and rotation) using homogeneous transformation matrices using MATLAB							02	
3.	To develop the forward kinematic model of a 2-DOF robotic manipulator using D-H parameters using MATLAB Robotics System Toolbox							02	
4.	To determine the inverse kinematics of a robotic manipulator for a given end-effector position using MATLAB Robotics System Toolbox							02	
5.	To generate and visualize the workspace of a robotic manipulator using MATLAB Robotics System Toolbox							02	
6.	To model and simulate the response of a DC servo motor used in robotic systems using Simulink							02	
7.	To design and tune a PID controller for robotic joint position control using MATLAB/Simulink							02	
8.	To perform stability analysis of a robotic control system using Root Locus and Bode Plot using MATLAB Robotics System Toolbox							04	
9.	To generate a trajectory for a robotic manipulator and simulate its motion using MATLAB Robotics System Toolbox							04	
10.	To simulate path planning and obstacle avoidance for a mobile robot in a virtual environment using MATLAB Robotics System Toolbox							04	
TOTAL								26	

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Reference Books:
1. Robotics and Control, by R K. Mittle, I J. Nagrath, Tata Mc Graw Hill. 2. Control Systems Engineering by Norman S. Nise , Pearsons. 3. Robot Manipulator Control, Theory and Practice – Frank Lewis, Darren Dawson. 4. Robotic Control by P. M. Taylor , Springer.
E-Resources:
1. https://nptel.ac.in/courses/107106081 Control Systems, IIT Madras 2. https://nptel.ac.in/courses/108103863 Control Engineering for Robotics, IIT Guwahati 3. https://nptel.ac.in/courses/112107289 Robotics and Control: Theory and Practice , IIT Roorke

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Quality Management System – III							Code: RAVS607		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	25	-	-	25
Prerequisites:									
Quality Management System – I, Quality Management System – II.									
Course Objectives:									
1. To understand basic principles and terms related to statistical process control.									
2. To understand Kaizen philosophy of continuous, incremental improvement & Six Sigma, data-driven methodology aimed at reducing defects and process variation.									
3. To understand processes in Business process management and know significance of concept customer driven quality.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Apply control charts for process controls to perform statistical analysis.								
CO2	Apply kaizen and six sigma for industrial processes								
CO3	Gain knowledge in customer relationship management								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Statistical process Control: Specification and control limits, types of control charts, control charts for variables and attributes, Pareto diagram, process flow diagram, cause and effect diagram, check sheets and histogram, Experimental design.								08
2.	Six Sigma and Kaizen- Continuous Improvement: Key six sigma concepts, quality level, three sigma's', defects per million opportunities, implementation, DMAIC, DMADV Concept of Kaizen, lean, 5S, kaizen vs innovation, CWQC, Kaizen practice, QFD, QCC, Poka yoke, quality of work life Taguchi quality engineering, loss function, orthogonal arrays, signal to noise ratio Parameter and tolerance design								09
3.	Customer driven quality and business process management: Customers perception of quality, customer relationship management and its components, customer retention programs CRM modules, CRM in B2B and B2C context, e- CRM. BMP: introduction and BMP implementation framework.								09
TOTAL								26	
Reference Books:									
1. Dale H. Besterfield, "Total Quality Management", Pearson Education.									
2. Poornima M. Charantimath, "Total Quality Management", Pearson, 2nd Edition.									
E-Resources:									
Quality Engineering & Management, https://onlinecourses.swayam2.ac.in/elearning/preview/nou25_me09									

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DEPARTMENT OF ROBOTICS AND AUTOMATION

Program: B. Tech. (Robotics and Automation Engineering)							Semester: VI		
Course: Internship – V							Code: RAIN605		
Teaching Scheme (Hrs./Week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	-	-	02	-	-	25	-	-	25

Preamble:

Internships serve as vital educational and career development experiences, offering practical exposure in a specific field. Employers seek individuals who possess the necessary skills and an understanding of industry environments, practices, and cultures. This internship is designed as a structured, short-term, supervised training program, often centered on specific tasks or projects with clear timelines. The primary goal is to immerse technical students in an industrial setting, providing experiences that cannot be replicated in the classroom. This exposure aims to develop competent professionals who understand the social, economic, and administrative factors influencing the operations of industrial organizations.

Course Objectives:

1. Exposure to students to the industrial environment, which cannot be provided in the classroom and hence creating deployable professionals for the industry.
2. Learn to implement the technical knowledge in real industrial situations.

Course Outcomes: After completion of this course, students will be able to -

CO1	Gain exposure to industry practices and understand how academic concepts are applied in professional settings.
CO2	Develop and demonstrate effective communication and teamwork skills within a work environment.
CO3	Improve your problem-solving and time management skills by working in real-world industry settings.

Internship Requirements

1. **Internship Duration:** It is mandatory for all students to undergo an internship after every semester during vacations for the duration of 3 to 5 weeks. Internships completed during this period will be considered for the assessment of Term Work (TW).
2. **Internship Opportunities:** Students can explore various opportunities for internships at:
 - f. Industries
 - g. Research labs or organizations
 - h. Collegiate clubs
 - i. In-house research projects
 - j. Online internships
3. **Support and Assistance:** Students can seek assistance for securing internships from:
 - e. The Training and Placement cell, along with departmental coordinators
 - f. Department or institute faculty members
 - g. Personal contacts
 - h. Directly connecting with industries or organizations
4. **Request Letter:** Once an industry, research organization, or collegiate club is identified, students must obtain a request letter from the concerned department or placement office. This letter, in the standard format must be duly signed by the authority, should be addressed to the HR manager or relevant authority.

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5. **Request Letter:** Once an industry, research organization, or collegiate club is identified, students must obtain a request letter from the concerned department or placement office. This letter, in the standard format must be duly signed by the authority, should be addressed to the HR manager or relevant authority.
6. **Confirmation Letter:** Students must submit the confirmation letter from the industry, research organization, or collegiate club to the Internship Coordinator and the Head of Department (HOD) office.
7. **Joining Report:** Upon commencing the internship, students must submit the joining report, joining letter, or a copy of the confirmation email to the Internship Coordinator and the HOD office.
8. **Faculty Mentor:** A faculty member will be assigned as a mentor to a group of students. The mentor will be responsible for monitoring, evaluating, and assessing student internship activities. The faculty mentor is also required to visit the internship location and submit formal feedback to the Internship Coordinator.
9. **Faculty Visits:** Faculty members are advised to visit the internship site once or twice during the internship period to monitor progress.
10. **Progress Report:** Students must submit progress report fortnightly to their faculty guide and the final internship report to the Internship Coordinator and department office.
11. **Evaluation Report:** After the completion of the internship, the mentor, along with the assessment panel members, should submit the evaluation report of the students to the department office and the Internship Coordinator.
12. **Internship Certificate:** Students must receive the Internship Certificate from the industry and submit it to the Internship Coordinator and department office.
13. **Presentation and Assessment:** Students are required to give a presentation on their internship work as part of the term work. The internship diary and report will also be verified and assessed.

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