University of Mumbai

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विद्याविषयक प्राधिकरणे
सभा आणि सेवा विभाग(ए.ए.एम.एस)
रूम नं. १२८ एम.जी.रोड, फोर्ट,
मुंबई – ४०० ०३२
टेलिफोन नं. – ०२२ – ६८३२००३३

(नॅक पुनर्मूल्यांकनाद्वारे ३.६५ (सी.जी.पी.ए.) सह अ++ श्रेणी
विद्यापीठ अनुदान आयोगाद्वारे श्रेणी १ विद्यापीठ दर्जा)

क्र.वि.प्रा.स.से./आयसीडी/२०२५-२६/३७ दिनांक : २७ मे, २०२५

परिपत्रक:-

सर्व प्राचार्य/संचालक, संलग्नित महाविद्यालये/संस्था, विद्यापीठ शैक्षणिक विभागांचे संचालक/ विभाग प्रमुख यांना कळविण्यात येते की, राष्ट्रीय शैक्षणिक धोरण २०२० च्या अमंलबजावणीच्या अनुषंगाने **शैक्षणिक वर्ष २०२५-२६** पासून **पदवी व पदव्युत्तर अभ्यासक्रम** विद्यापरिषदेच्या दिनांक २८ मार्च २०२५ व २० मे, २०२५ च्या बैठकीमध्ये मंजूर झालेले सर्व अभ्यासक्रम मुंबई विद्यापीठाच्या www.mu.ac.in या संकेत स्थळावर NEP २०२० या टॅब वर उपलब्ध करण्यात आलेले आहेत.

मुंबई – ४०० ०३२
२७ मे, २०२५

(डॉ. प्रसाद कारंडे)
कुलसचिव

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8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
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2	**Faculty of Humanities,** **Offg. Dean** 1. Prof.Anil Singh Dranilsingh129@gmail.com **Offg. Associate Dean** 2. Prof.Manisha Karne mkarne@economics.mu.ac.in 3. Dr.Suchitra Naik Naiksuchitra27@gmail.com
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AC – 20/5/2025
Item No. – 6.59 (N)

As Per NEP 2020

M.Tech. (Robotics and Process Automation)

Syllabus for

First Year M. Tech. – Sem I & II

Second Year M. Tech. – Sem III & IV

Ref: GR dated 16th May, 2023 for Credit Structure of PG

With Effective from A.Y. 2025-2026

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars	
1	**Title of program** **O. TEP-1A**	**A**	**M.Tech. in (Robotics and Process Automation)**
2	**Eligibility** **O. TEP-1A**	**A**	Any Engineering Graduate with a Four-year Engineering Course recognized degree in any program. **OR** Any Engineering Graduate with four years UG Engineering Degree program (Honours / Honours with Research) with 18 credits in Minor subject. **OR** Any Engineering Graduate with 4-year U.G. Degree (Honours / Honours with Research) with Specialization in any Engineering stream or passed equivalent Academic Level 6.0 **OR** Mention any other eligibility criteria (if any), as per National Credit Framework (N.Cr.F) 2023 with Academic Level 6.0 **OR** Passed equivalent Academic Level 6.0
3	**Duration of program** **R. TEP-1**	**A**	2 Year
4	**R. TEP-2 Intake Capacity**		
5	**R. TEP-3 Scheme of Examination**		NEP 50% Internal 50% External, Semester End Examination Individual Passing in Internal and External Examination

6	**Standards of Passing** **R. TEP-4**	45%	
7	**Credit Structure** **Sem I - R. TEP-5A** **Sem II - R. TEP-5B** **Sem III - R. TEP-5C** **Sem IV - R. TEP-5D**	Attached herewith **Sem I & II R: 41 Credit** **Sem. I - R: 21 Credit** **Sem. II - R: 20 Credit** **Sem III & IV R: 40 Credit** **Sem. III - R: 20 Credit** **Sem. IV - R: 20 Credit**	
8	**Semesters**	**A**	Sem. I, II, III& IV
9	**Program Academic Level**	**A**	7.0
10	**Pattern**	Semester	
11	**Status**	New	
12	**To be implemented from Academic Year**	A	2025-26

Sd/- **Dr. S. K. Shinde** **BoS-Chairman-Computer Engineering** **Faculty of Technology,** **University of Mumbai**	**Sd/-** **Dr. Deven Shan** **Offg. Associate Dean** **Faculty of Science & Technology,** **University of Mumbai.**	**Sd/-** **Dr. Shivram Garge** **Offg. Dean** **Faculty of Science & Technology,** **University of Mumbai.**

Preamble

Introduction: Robotics and Process Automation is an interdisciplinary field that combines mechanical engineering, electronics, computer science, and artificial intelligence to design, develop, and implement intelligent systems and automated processes. The M.Tech in Robotics and Process Automation is a postgraduate program designed to prepare students for a dynamic career in industries where robotics and automation play a critical role in enhancing productivity and innovation.

This program focuses on advanced robotics systems, control engineering, sensor integration, machine learning, and industrial process automation, equipping students with both theoretical knowledge and hands-on experience.

Aims and Objectives:

- To provide in-depth knowledge of robotics engineering and automation systems used in modern industrial applications.
- To develop advanced technical skills in robotics control, AI, machine vision, IoT integration, and cyber-physical systems.
- To promote innovation and research in robotic system design and intelligent process automation.
- To foster interdisciplinary problem-solving abilities and project management skills for real-world automation challenges.

Learning Outcomes:

- Ability to design, simulate, and implement robotic systems for varied industrial and service applications.
- Proficiency in programming and controlling robots using real-time operating systems, PLCs, and embedded platforms.
- Skills to integrate sensors, actuators, and controllers to develop autonomous and semi-autonomous systems.
- Understanding of ethical, safety, and societal implications of deploying automation technologies.
- Capability to lead automation projects and contribute to R&D in robotics and smart manufacturing.

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Credit Structure of the Program (Sem I, II, III & IV)

Post Graduate Certificate in (M.Tech. (Robotics and Process Automation)

Credit Structure (Sem. I, II, III & IV)

Post Graduate Programs at the University

Sem I - R. TEP-5A
Sem II - R. TEP-5B

Year (2 Yr PG)	**Level**	**Sem.** (2 Yr)	**Major**		**RM**	**OJT / FP**	**RP**	**Cum. Cr.**	**Degree**
			Mandatory*	**Electives Any one**					
I	**6.5**	**Sem I**	**Credits 3** Course 1 = 3 Credits 2 = 3 Course 3 = 3 **Lab Credits 1** Lab1 =1 Lab2 =1 Lab3 =1 **Lab Credits 2** Lab4 =2	**Credits 3** Course 1=3 **Lab Credits 1** Lab1 =1	**Credits 3** RM Course = 3	--	--	21	**PG (after 4 years Engineering Degree)**
		Sem II	**Credits 3** Course 1 = 3 Credits 2 = 3 Course 3 = 3 **Lab Credits 1** Lab1 =1 Lab2 =1 Lab3 =1	**Credits 3** Course 1=3 **Lab Credits 1** Lab1 =1	--	**Credits 4** OJT/FP =4	--	20	
Cum. Cr. For PG First Year			**26**	**8**	**3**	**4**	**-**	**41**	

Sem III - R. TEP-5C
Sem IV - R. TEP-5D

II	**7.0**	**Sem III**	**Credits 3** Course 1 = 3 Credits 2 = 3 Course 3 = 3 **Lab Credits 1** Lab1 =1 Lab2 =1 Lab3 =1	**Credits 3** Course 1=3 **Lab Credits 1** Lab1 =1			**Credits 4** RP =4	20	**PG (after 4 years Engineering Degree)**
		Sem IV	**Credits 3** Course 1 = 3 Credits 2 = 3 **Lab Credits 1** Lab1 =1 Lab2 =1 **Lab Credits 2** Lab3 =2	**Credits 3** Course 1=3 **Lab Credits 1** Lab1 =1			**Credits 6** RP =6	20	
Cum. Cr. for 1 Yr PG Degree			**22**	**8**			**10**	**40**	
Cum. Cr. for 2 Yr PG Degree			**48**	**16**	**3**	**4**	**10**	**81**	

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Sd/-
Dr. Shivram Garge **Offg.**
Dean
Faculty of Science & Technology,
University of Mumbai.

Program Structure for M. Tech. in Robotics & Process Automation

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER I

Course Code	Course Title	Teaching Scheme (Contact Hours)			Credit	EVALUATION SCHEME							
						IA-I	IA-II	IA-I + IA-II	End Sem Exam	Exam duration in hrs.	Term Work	Practical & Oral Exam	Total
		L	**T**	**P**									
RPAPC101	Fundamental of Robotics	3		--	3	20	20	40	60	2	--	--	100
RPAPC102	Microcontroller applications in automation	3	--	--	3	20	20	40	60	2	--	--	100
RPAPC103	Process Control & Instrumentation	3	--	--	3	20	20	40	60	2	--	--	100
RPAPC104	Research Methodology & Intellectual Property Rights	3	--	--	3	20	20	40	60	2	--	--	100
RPAPE101	Elective-I	3	--	--	3	20	20	40	60	2	--	--	100
RPAPCL101	Robotics Lab	-	--	2	1	--	--	--	--	--	25	25	50
RPAPCL102	Microprocessor & Microcontroller Lab	--	--	2	1	--	--	--	--	--	25	25	50
RPAPCL103	Process Control & Instrumentation Lab	--	--	2	1	--	--	--	--	--	25	25	50
RPAPEL101	Elective-I	--	--	2	1	--	--	--	--	--	25	25	50
RPAVECL101	Programming Techniques Laboratory	--	--	4	2	--	--	--	--	--	50	--	50
TOTAL		**15**	**--**	**12**	**21**	**100**	**100**	**200**	**300**	**10**	**150**	**100**	**750**

RPAPE101	Elective -I	a) Artificial Intelligence and Expert Systems in Automation b) Digital Image Processing and Computer vision c) Mechatronic Devices and Systems

Program Structure for M. Tech. in Robotics & Process Automation

UNIVERSITY OF MUMBAI (With Effect from 2025-2026)

SEMESTER II

Course Code	Course Title	Teaching Scheme (Contact Hours)			Credit	EVALUATION SCHEME							
						IA-I	IA-II	IA-I + IA-II	End Sem Exam	Exam duration in hrs.	Term Work	Practical & Oral Exam	Total
		L	**T**	**P**									
RPAPC201	Automation System Design	3		--	3	20	20	40	60	2	--	--	100
RPAPC202	Industrial Automation	3	--	--	3	20	20	40	60	2	--	--	100
RPAPC203	Industrial Internet of Things	3	--	--	3	20	20	40	60	2	--	--	100
RPAPE201	Elective-II	3	--	--	3	20	20	40	60	2	--	--	100
RPAOJT201	Internship/Field Project	Entire Semester			4	--	--	--	--	--	100	100	200
RPAPCL201	Automation System Design Lab	--	--	2	1	--	--	--	--	--	25	25	50
RPAPCL202	Industrial Automation Lab	--	--	2	1	--	--	--	--	--	25	25	50
RPAPCL203	Industrial Internet of Things Lab	--	--	2	1	--	--	--	--	--	25	25	50
RPAPEL201	Elective-II Lab	--	--	2	1	--	--	--	--	--	25	25	50
TOTAL		**12**	**00**	**08**	**20**	**80**	**80**	**160**	**240**	**08**	**200**	**200**	**800**

RPAPE201	a) Swarm Intelligence b) Optimization Algorithms c) Computational Intelligence

Program Structure for M. Tech. in Robotics & Process Automation

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER III

Course Code	Course Title	Teaching Scheme (Contact Hours)			Credit	EVALUATION SCHEME							
						IA-I	IA-II	IA-I + IA-II	End Sem Exam	Exam duration in hrs.	Term Work	Practical & Oral Exam	Total
		L	**T**	**P**									
RPAPC301	Product Design & Development	3		--	3	20	20	40	60	2	--	--	100
RPAPC302	Machine Learning	3	--	--	3	20	20	40	60	2	--	--	100
RPAPC303	Embedded System Design	3	--	--	3	20	20	40	60	2	--	--	100
RPARP301	Research Project	Entire Semester			4	--	--	--	--	--	100	100	200
RPAPE301	Elective-III	3	--	--	3	20	20	40	60	2	--	--	100
RPAPCL301	Product Design & Development Lab	-	--	2	1	--	--	--	--	--	25	25	50
RPAPCL302	Machine Learning Lab	--	--	2	1	--	--	--	--	--	25	25	50
RPAPCL303	Embedded System Design Lab	--	--	2	1	--	--	--	--	--	25	25	50
RPAPEL301	Elective-III Lab	--	--	2	1	--	--	--	--	--	25	25	50
TOTAL		**12**	**--**	**08**	**20**	**80**	**80**	**160**	**240**	**08**	**200**	**200**	**800**

RPAPE301	Elective -III	a) CNC Machines b) Advanced Process Control c) Robotics for Industrial Automation

Program Structure for M. Tech. in Robotics & Process Automation

UNIVERSITY OF MUMBAI (With Effect from 2026-2027)

SEMESTER IV

Course Code	Course Title	Teaching Scheme (Contact Hours)			Credit	EVALUATION SCHEME							
						IA-I	IA-II	IA-I + IA-II	End Sem Exam	Exam duration in hrs.	Term Work	Practical & Oral Exam	Total
		L	**T**	**P**									
RPAPC401	Cyber-Physical Product Design for Robotics & Automation	3		--	3	20	20	40	60	2	--	--	100
RPAPC402	Reinforcement Learning & Control in Robotics	3	--	--	3	20	20	40	60	2	--	--	100
RPARP401	Research Project	Entire Semester			6	--	--	--	--	--	200	100	300
RPAPE401	Elective-IV	3	--	--	3	20	20	40	60	2	--	--	100
RPAPCL401	Cyber-Physical Product Design Lab	-	--	2	1	--	--	--	--	--	25	25	50
RPAPCL402	Autonomous Robotics & Reinforcement Learning Lab	--	--	2	1	--	--	--	--	--	25	25	50
RPAPCL403	Autonomous Systems Programming Lab	--	--	2*+2	2	--	--	--	--	--	25	25	50
RPAPEL401	Elective-IV Lab	--	--	2	1	--	--	--	--	--	25	25	50
TOTAL		**09**	**--**	**10**	**20**	**60**	**60**	**120**	**180**	**06**	**300**	**200**	**800**

RPAPE401	Elective -IV	a) CNC Robotics and Intelligent Machining b) AI-Driven Process Control & Automation c) Advanced Robotics for Industrial Automation

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC101	Fundamental of Robotics	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC101	Fundamental of Robotics	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Robotics is an interdisciplinary branch of electronic engineering and mechanical engineering. Robotics involves design, construction, operation, and use of robots. The goal of robotics is to design machines thatcan help and assist humans. Robotics integrates fields of mechanical engineering, electrical engineering, information engineering, Mechatronics, electronics, bioengineering, computer engineering, control engineering, software engineering, mathematics, etc.

Course Objectives:

The objectives of this course are to:

1. Understand and discuss the fundamental elementary concepts of Robotics.
2. Provide insight into different types of robots.
3. Explain intelligent module for robotic motion control.
4. Educate on various path planning techniques.
5. Illustrate the working of innovative robotic devices.
6. Illustrate the application of Robotics.

Course Outcomes:

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

1: Understand the significance, social impact and future prospects of robotics and automation in various engineering applications.

2: Identify and describe the components and anatomy of robotic system.

3: Know about various path planning techniques and analyze different motions of robotics system

4: Use the suitable drives and end-effectors for a given robotics application.

5: Apply robotics concept to automate the monotonous and hazardous tasks and categorize various types of robots based on the design and applications in real world scenarios.

6: Application of Robotics in various domain.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Calculus, Probability, C++, python, microcontroller and embedded system.	**2**	--
I	**Introduction To Robotics**	Introduction to Robotics and Automation, laws of robot, brief history of robotics, basic components of robot, robot specifications, classification of robots, human system and robotics, safety measures in robotics, social impact, Robotics market and the future prospects, advantages and disadvantages of robots.	**6**	**CO1**
II	**Robot Anatomy And Motion Analysis**	Anatomy of a Robot, Robot configurations: polar, cylindrical, Cartesian, and jointed arm configurations, Robot links and joints, Degrees of freedom: types of movements, vertical, radial and rotational traverse, roll, pitch and yaw, Wok volume/envelope, Robot kinematics: Introduction to direct and inverse kinematics, transformations and rotation matrix.	**7**	**CO2**
III	**Robot Drives And End Effectors**	Robot drive systems: Hydraulic, Pneumatic and Electric drive systems, classification of end effectors, mechanical grippers, vacuum grippers, magnetic grippers, adhesive gripper, gripper force analysis and gripper design, 1 DoF, 2 DoF, multiple degrees of freedom robot hand, tools as end effectors, Robot control types: limited sequence control, point-to-point control, playback with continuous path control, and	**7**	**CO3**

		intelligent control.		
IV	**Path Planning**	Definition-Joint space technique, Use of P-degree polynomial-Cubic, polynomial-Cartesian space technique, parametric descriptions, straight line and circular paths, position and orientation planning.	**6**	**CO4**
V	**Robotics Material Handling**	pick and place, palletizing and depalletizing, machining loading and unloading, welding & assembly, Medical, agricultural and space applications, unmanned vehicles: ground, Ariel and underwater applications, robotic for computer integrated manufacturing. Types of robots: Manipulator, Legged robot, wheeled robot, aerial robots, Industrial robots, Humanoids, Robots, Autonomous robots, and Swarm robots	**7**	**CO5**
VI	**Robotics Applications**	Industry, Healthcare and medicine, Agriculture and Food Industry, Autonomous Vehicles and Drones, Military and Defense Robotics etc.	**4**	**CO6**

Text Books:

1. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education, 2009.
2. Mikell P. Groover et. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, Special Edition, (2012).
3. Ganesh S Hegde, "A textbook on Industrial Robotics", University science press, 3rdedition,2017.

References:

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.
2. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics: Control, Sensing, Vision and Intelligence",McGrawHill, 1987. https://www.robots.com/applications.

Online References:

Website Name
1. https://roboticscasual.com/ros-tutorial-pick-and-place-task-with-the-moveit-c-interface/ 2. https://roboticscasual.com/ros-tutorial-simulate-ur5-robot-in-gazebo-urdf-explained/ 3. https://roboticscasual.com/the-best-degrees-to-work-in-robotics/ 4. https://roboticscasual.com/robotics-tutorials/ 5. https://www.ieee-ras.org/educational-resources-outreach/educational-material-in-robotics-and- automation 6. https://www.academia.edu/20361073/Web_Based_Control_and_Robotics_Education_pdf 7. https://github.com/Developer-Y/cs-video-courses 8. https://www.isa.org/ 9. https://www.asme.org/engineering-topics/articles/bioengineering/top-6robotic-applications-in- medicine.

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC102	Microcontroller applications in automation	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC102	Microcontroller applications in automation	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

The course integrates embedded programming, sensor interfacing, communication protocols, and real-time control to enable students to design and develop automated systems for industrial, home, and smart applications.

Course Objectives:

The objectives of this course are to:

1. Understand the architecture, features, and functionalities of microcontrollers used in automation.
2. Interfacing Peripherals and Actuators
3. Interface microcontrollers with sensors, actuators, and communication modules for automation.
4. Implement communication protocols (UART, SPI, I2C, CAN, MODBUS) for industrial applications.
5. Integrate IoT and cloud-based technologies in microcontroller automation systems.
6. Design and implement real-world microcontroller-based automation projects for home, industry, and smart applications.

Course Outcomes:

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

1: Describe the architecture and features of microcontrollers used in automation.

2: Interfacing Peripherals and Actuators

3: Interface sensors and communication modules with microcontrollers for real-time control.

4: Implement communication protocols for industrial automation applications.

5: Integrate IoT and cloud-based technologies to create smart automation systems.

6: Develop a real-world microcontroller-based automation project for home, industrial, or IoT-based applications.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic knowledge of digital electronics (Boolean algebra, logic gates, flip-flops). Microprocessors and microcontrollers.	**2**	--
I	**Introduction to Microcontrollers and Automation**	Introduction to microcontrollers (8051, PIC, AVR, ARM, ESP32) Difference between micro-processors and micro-controllers. Microcontroller architecture: Memory organization, timers, interrupts. Role of microcontrollers in industrial automation.	**6**	**CO1**
II	**Interfacing Peripherals and Actuators**	GPIO configuration for input/output operations. Timers and interrupts in microcontrollers. Interfacing DC motors, stepper motors, and servo motors. Controlling solenoids, relays, and other actuators. Pulse Width Modulation (PWM) for speed and position control.	**7**	**CO2**
III	**Sensor Integration for Automation**	Working principles of temperature, humidity, proximity, IR, ultrasonic, and gas sensors. Analog to Digital Conversion (ADC) and Digital to Analog Conversion (DAC). Real-time data acquisition and processing using microcontrollers. Smart sensing and data logging for industrial automation	**7**	**CO3**
IV	**Communication Protocols in Automation**	Introduction to communication protocols (UART, SPI, I2C, CAN, MODBUS, RS-485). Wireless communication (Wi-Fi, Bluetooth, Zigbee, LoRa). Interfacing microcontrollers with external devices using I2C and SPI. Industrial applications of communication protocols.	**6**	**CO4**
V	**IoT-Based Automation and**	Introduction to IoT and cloud-based automation. ESP32-based IoT	**7**	**CO5**

	Cloud Integration	applications. MQTT protocol for cloud connectivity. Remote monitoring and control using Firebase/AWS IoT. Security aspects in IoT automation.		
VI	**Real-Time Applications and Case Studies**	Home automation: Smart lighting, security systems. Industrial automation: Conveyor belt control, robotic arms. Agriculture automation: Smart irrigation using IoT. AI integration with microcontrollers (Edge AI, TinyML). Design and development of a final project using microcontrollers	**4**	**CO6**

Text Books:

1. "The 8051 Microcontroller and Embedded Systems" – Muhammad Ali Mazidi, Janice Mazidi
2. "PIC Microcontroller and Embedded Systems" – Muhammad Ali Mazidi, Rolin McKinlay, Danny Causey
3. "Embedded Systems: Real-Time Interfacing to ARM Cortex-M" – Jonathan W. Valvano
4. "Introduction to Embedded Systems" – Shibu K.V.

References:

1. "AVR Microcontroller and Embedded Systems" – Muhammad Ali Mazidi, Sarmad Naimi
2. "ARM System Developer's Guide" – Andrew Sloss, Dominic Symes
3. "Embedded Systems: Architecture, Programming, and Design" – Raj Kamal
4. "Programming Embedded Systems in C and C++" – Michael Barr

Online References:

Website Name
1. **Coursera – "Embedded Systems – Shape the World" (University of Texas at Austin)** https://www.coursera.org/learn/embedded-systems 2. **MIT OpenCourseWare – "Embedded Systems"** https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/ 3. **NPTEL – "Microcontrollers and Embedded Systems"** https://nptel.ac.in/courses/108/105/108105102/ 4. **ESP32 Official Documentation** https://docs.espressif.com/projects/esp-idf/en/latest/esp32/ 5. **Arduino Reference** https://www.arduino.cc/reference/en/

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC103	Process Control & Instrumentation	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC103	Process Control & Instrumentation	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Process Control & Instrumentation focuses on monitoring, controlling, and optimizing industrial processes to ensure efficiency, safety, and automation. The course introduces measurement techniques, control systems, feedback mechanisms, and digital control systems used in industries such as manufacturing, oil & gas, power plants, pharmaceuticals, and robotics**.**

Course Objectives:

The objectives of this course are to:

1. Understand fundamental principles of industrial instrumentation and process control.
2. Analyze and design process control loops using sensors, controllers, and actuators.
3. Apply control techniques such as PID, feedforward, and cascade control.
4. Implement PLC, SCADA, and IoT-based process automation solutions.
5. Optimize industrial processes for efficiency, safety, and cost-effectiveness.
6. Develop practical skills in simulation and real-time control applications.

Course Outcomes:

Upon successful completion, students will be able to:

1. Analyze industrial processes and select appropriate control techniques.
2. Design, implement, and tune PID controllers for various process applications.
3. Integrate sensors, actuators, and instrumentation systems for automation.
4. Develop PLC and SCADA-based industrial control systems.
5. Implement digital control strategies for real-time industrial applications.
6. Apply process optimization and fault detection techniques in industry.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic Electrical & Electronics Engineering. Sensors & Transducers. Mathematics (Laplace Transform, Differential Equations, Probability & Statistics). Control System Engineering. Programming (MATLAB, Python, or Ladder Logic for PLCs).	**2**	--
I	**Fundamentals of Process Control & Instrumentation**	Introduction to process control systems. Types of control systems: Open-loop vs. Closed-loop. Measurement principles: pressure, temperature, flow, level. Dynamic behavior of processes: first-order and second-order systems. Dynamic response analysis. Block diagrams and transfer functions. Calibration and standards in instrumentation.	**6**	**CO1**
II	**Process Control Elements & Controllers**	Sensors, actuators, and final control elements. Pneumatic, hydraulic, and electrical controllers. Types of controllers: ON/OFF, Proportional (P), Integral (I), Derivative (D), PID. PID Controller tuning techniques. Control valve types, characteristics, and selection criteria. Tuning methods: Ziegler-Nichols and Cohen-Coon methods	**7**	**CO2**
III	**Advanced Control Strategies**	Cascade control, feedforward control, ratio control. Adaptive and model predictive control (MPC). Multivariable process control. Design and implementation of advanced controllers. Performance comparison of different control strategies Industrial examples of control applications. Case studies: Heat exchanger control, boiler control. Stability analysis and controller design	**7**	**CO3**
IV	**Digital Control Systems &**	Introduction to Programmable Logic Controllers (PLC). PLC architecture, programming	**6**	**CO4**

	Automation	languages (Ladder Logic, Function Block). Supervisory Control and Data Acquisition (SCADA) systems. Distributed Control Systems (DCS). IoT-enabled industrial automation.		
V	**Industrial Process Measurement & Instrumentation**	Flow measurement: Orifice plate, Venturi, Ultrasonic, Coriolis. Level measurement: Capacitive, Radar, Ultrasonic sensors. Temperature measurement: RTD, Thermocouples, Infrared sensors Pressure measurement: Bourdon tube, Strain gauge, Piezoelectric sensors. Signal conditioning and data acquisition systems.	**7**	**CO5**
VI	**Applications in Real-Time Industrial Systems**	Process control in power plants, oil & gas, food processing. Automation in chemical and pharmaceutical industries. Smart factories and cyber-physical systems. Fault detection and predictive maintenance. Future trends: AI in process control, Edge computing.	**4**	**CO6**

Text Books:

1. "Process Control: Modeling, Design, and Simulation" – B. Wayne Bequette
2. "Process Systems Analysis and Control" – Donald R. Coughanowr, Steven E. LeBlanc
3. "Industrial Instrumentation and Control" – S. K. Singh
4. "Modern Control Engineering" – Katsuhiko Ogata

References:

1. "Instrumentation and Process Control" – William C. Dunn
2. "Process Dynamics and Control" – Seborg, Edgar, Mellichamp
3. "Industrial Automation and Process Control" – Jon Stenerson
4. "Control Systems Engineering" – Norman S. Nise

Online References:

Website Name
1. MIT OpenCourseWare – "Process Dynamics and Control" https://ocw.mit.edu/courses/chemical-engineering/
2. NPTEL – "Industrial Automation and Control" https://nptel.ac.in/courses/108/105/108105062/
3. Coursera – "Process Control and Instrumentation"

https://www.coursera.org/courses?query=process%20control

4. PLC and SCADA Tutorials
   https://www.plcacademy.com/
5. ISA (International Society of Automation) Training
   https://www.isa.org/training

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC104	Research Methodology & Intellectual Property Rights	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC104	Research Methodology & Intellectual Property Rights	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course covers systematic research methods, data collection techniques, qualitative and quantitative analysis, and research ethics. Additionally, it introduces Intellectual Property Rights (IPR), patents, copyrights, trademarks, and their role in innovation and commercialization.

Course Objectives:

This course aims to:

1. Understand the fundamentals of research methodology, including problem formulation and hypothesis development.
2. Develop skills in data collection, statistical analysis, and interpretation of research findings.
3. Learn different research approaches, including experimental, analytical, and qualitative techniques.
4. Understand the role of Intellectual Property Rights (IPR) in research and innovation.
5. Explore the process of patent filing, copyright laws, trademarks, and industrial designs.

6. Promote ethical research practices and understand the impact of plagiarism and research misconduct.

Course Outcomes:

Upon successful completion, students will be able to:

1. Understand research methodologies and formulate well-defined research problems.
2. Use appropriate data collection and analysis techniques in research.
3. Write research papers, theses, and technical reports effectively.
4. Demonstrate knowledge of Intellectual Property Rights and their significance in innovation.
5. Conduct patent searches, draft patents, and understand the process of IP protection.
6. Apply legal and ethical considerations in research and innovation.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic statistics and data analysis methods.	**2**	--
I	**Introduction to Research Methodology**	Definition and objectives of research. Research types: Fundamental, applied, analytical, qualitative, quantitative. Research process: Problem identification, literature review, hypothesis formulation. Research design and methods. Ethical issues in research.	**6**	**CO1**
II	**Data Collection, Analysis, and Interpretation**	Sources of data: Primary and secondary sources. Data collection methods: Surveys, case studies, interviews, experiments. Sampling techniques and data validation. Quantitative and qualitative analysis methods. Statistical tools: SPSS, R, MATLAB, Excel for data analysis.	**7**	**CO2**
III	**Technical Writing and Research Communication**	Structure of a research paper, thesis, and dissertation. Referencing styles (APA, IEEE, MLA). Use of reference	**7**	**CO3**

		management tools: Mendeley, EndNote, Zotero. Writing research proposals and grant applications. Publication process: Journals, conferences, impact factor, citation index		
IV	**Introduction to Intellectual Property Rights (IPR)**	Introduction to IPR: Need and significance. Types of Intellectual Property (IP): Patents, copyrights, trademarks, industrial designs, trade secrets. Patent system in India and worldwide. Process of patent filing and examination. Patent infringement and litigation.	**6**	**CO4**
V	**Patent Search, Drafting, and Filing**	Patentability criteria: Novelty, non-obviousness, industrial application. Patent search tools: Google Patents, WIPO, USPTO, Espacenet. Patent drafting: Provisional and complete specification. Filing process: National and international patent applications. IP commercialization and technology transfer	**7**	**CO5**
VI	**Legal Aspects, Copyrights, and Trademarks**	Trademark registration process and its significance. Copyright laws and protection of creative works. Industrial designs and geographical indications. Case studies on IP disputes and infringement. IP laws in India: The Patents Act, Copyright Act, Trademark Act.	**4**	**CO6**

Text Books:

1. "Research Methodology: Methods and Techniques" – C.R. Kothari, Gaurav Garg
2. "Research Methodology: A Step-by-Step Guide for Beginners" – Ranjit Kumar
3. "Intellectual Property Rights" – Deborah E. Bouchoux
4. "Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" – William M. Landes

References:

1. "Design and Analysis of Experiments" – Douglas C. Montgomery
2. "Patent Law for Scientists and Engineers" – Howard B. Rockman

3. "Manual of Patent Examining Procedure" – USPTO
4. "WIPO Handbook on Intellectual Property Rights" – World Intellectual Property Organization (WIPO)

Online References:

Website Name
1. Coursera – "Understanding Research Methods" **https://www.coursera.org/learn/research-methods** **2.** NPTEL – "Research Writing and Technical Communication" https://nptel.ac.in/courses/109/106/109106149/ **3.** WIPO – "Patent Search and Drafting" https://www.wipo.int/academy/en/courses/ **4.** Google Patents & USPTO Patent Search **https://patents.google.com/** https://www.uspto.gov/patents/search **5.** MIT OpenCourseWare – "Intellectual Property Law and Policy" https://ocw.mit.edu/courses/economics/

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL 101	Robotics Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA -I	IA-II	IA-I + IA-II				
RPAPCL101	Robotics Lab	--	--	--	--	25	25	50

This Robotics Lab is designed to provide hands-on experience in robot design, programming, and control. Students will work with robotic hardware, microcontrollers, sensors, actuators, and simulation tools to develop real-world robotic applications. The course covers kinematics, path planning, sensors, vision systems, and AI-based robotic control.

Lab Objectives:

The objectives of this lab are to:

1. Understand the fundamentals of robotic systems, including kinematics and dynamics.
2. Develop programming skills for robot control using microcontrollers and simulation tools.
3. Interface sensors and actuators for autonomous robotic applications.
4. Implement vision-based robotics using image processing and machine learning.
5. Develop motion planning and path-following algorithms for mobile robots.
6. Work on real-time robotic projects integrating IoT, AI, and automation.

Lab Outcomes:

Upon completing this lab, students will be able to:

1. Understand robotic kinematics and implement motion algorithms.

2. Develop embedded programs for robotic actuation and control.
3. Integrate and calibrate sensors for autonomous robotic applications.
4. Implement AI and vision-based control for intelligent robotics.
5. Develop navigation and path-planning solutions for mobile robots.
6. Design and prototype IoT-based robotics applications.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Python/Mathlab	02	
I	**Introduction to Robotics and Kinematics**	Introduction to robots, types, and applications. Forward and inverse kinematics for robotic arms. Basic motion programming for robotic joints.	**04**	**LO1**
II	**Robotic Motion Control and Actuation**	DC motors, servo motors, stepper motors in robotics. PID control for precise motion. PWM-based speed control of motors.	**04**	**LO2**
III	**Sensor Integration and Feedback Systems**	Proximity, ultrasonic, IR, and LIDAR sensors. Gyroscope and accelerometer for robot orientation Sensor fusion for autonomous robots.	**04**	**LO3**
IV	**Computer Vision and AI in Robotics**	Basics of image processing using OpenCV. Object detection using AI models (YOLO, Haar cascades). Robot navigation using vision sensors.	**04**	**LO4**
V	**Robotic Path Planning and Navigation**	Graph-based path planning (Dijkstra, A*). Localization and mapping (SLAM). Robot navigation using GPS and IMU	**04**	**LO5**
VI	**IoT and Cloud Robotics**	Cloud-based robotics control. IoT-enabled robot monitoring. Wireless communication in robotics	**04**	**LO6**

Text Books:

1. "Introduction to Robotics: Mechanics and Control" – John J. Craig
2. "Robot Modeling and Control" – Mark W. Spong

3. "Modern Robotics: Mechanics, Planning, and Control" – Kevin M. Lynch & Frank C. Park
4. "Embedded Robotics: Mobile Robot Design and Applications" – Thomas R. Kurfess

References:

1. "Springer Handbook of Robotics" – Bruno Siciliano, Oussama Khatib
2. "Probabilistic Robotics" – Sebastian Thrun, Wolfram Burgard
3. "Artificial Intelligence: A Guide for Thinking Humans" – Melanie Mitchell
4. "Deep Learning for Computer Vision" – Rajalingappaa Shanmugamani

Online Resources:

Website Name
1. MIT OpenCourseWare – "Introduction to Robotics" https://ocw.mit.edu/courses/mechanical-engineering/ 2. Coursera – "Modern Robotics: Mechanics, Planning, and Control" https://www.coursera.org/specializations/modernrobotics 3. Stanford AI Lab – "CS223A: Robotics Foundations" http://cs223a.stanford.edu/ 4. ROS (Robot Operating System) Tutorials https://wiki.ros.org/Tutorials 5. OpenCV Python Tutorials for Computer Vision https://opencv.org/courses/

List of Experiments.

Sr No	List of Experiments	Hrs
01	Forward kinematics of a 2 DOF robotic arm using Python/MATLAB.	02
02	Inverse kinematics for a 3 DOF robotic arm using simulation.	02
03	Interfacing a DC motor with Arduino/Raspberry Pi for speed control.	02
04	Implementing PID control for a robotic arm using MATLAB/Python.	02
05	Interfacing an ultrasonic sensor for obstacle detection.	02

06	Implementing a line-following robot using IR sensors.	02
07	Implementing color object tracking using OpenCV.	02
08	Face recognition-based robot movement using AI.	02
09	Implementing *A algorithm for robotic path planning**.	02
10	Building a self-navigating robot using GPS and IMU.	02
11	Controlling a robot remotely via MQTT protocol.	02
12	Building a cloud-connected robot using ESP32 and Firebase.	02

Sr No	List of Assignments / Tutorials	Hrs
01	• Write a report on different types of robots and their applications. • Simulate a robotic arm movement using RoboAnalyzer/Webots/V-REP.	02
02	• Write a program for servo motor angle control using microcontrollers. • Implement a PWM speed control algorithm for a robotic wheel.	02
03	• Compare sensor technologies used in autonomous robotics. • Develop a collision avoidance algorithm using sensor feedback.	02
04	• Train a custom AI model for object detection in robotics. • Implement edge detection for robotic vision.	02
05	• Write a report on SLAM algorithms used in autonomous robots. • Simulate a mobile robot navigating an obstacle course.	02
06	• Develop a voice-controlled robot using IoT and Google Assistant. • Study and compare IoT-based robotics platforms.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL 102	Microprocessor & Microcontroller Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL102	Microprocessor & Microcontroller Lab	--	--	--	--	25	25	50

This lab course provides hands-on experience **with** microprocessors (8085/8086) and microcontrollers (8051, PIC, AVR, ARM, ESP32). Students will develop programming skills, interface peripherals, and build automation-based applications using real-time embedded systems.

Lab Objectives:

This lab aims to:

1. Understand the architecture and working of microprocessors and microcontrollers.
2. Develop assembly and embedded C programming skills for microcontrollers.
3. Interface various peripherals, such as sensors, motors, and displays.
4. Implement communication protocols (UART, I2C, SPI) for data transfer.
5. Explore real-world applications of microcontrollers in automation and IoT.
6. Work on hands-on projects that simulate real-time industrial applications.

Lab Outcomes:

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

1. Write and execute assembly and embedded C programs for microprocessors and microcontrollers.
2. Interface sensors, motors, and other peripherals with microcontrollers for real-time applications.
3. Implement serial and parallel communication protocols in automation systems.
4. Develop embedded systems using wireless connectivity (Wi-Fi, Bluetooth, Zigbee).
5. Integrate IoT-based automation solutions using microcontrollers.
6. Work on real-world projects that apply microcontroller knowledge to industrial and smart applications.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	C Programming.	02	
I	**Introduction to Microprocessors & Microcontrollers**	Difference between micro-processors and microcontrollers. Introduction to 8085, 8086, 8051, PIC, AVR, and ARM-based microcontrollers. Basics of Assembly language and Embedded C programming. Instruction set, addressing modes, and memory organization	**04**	**LO1**
II	**Programming Microcontrollers in Embedded C**	Introduction to Keil, MPLAB, Arduino IDE, and ESP-IDF for microcontroller programming. GPIO operations and bitwise manipulation. Timers, counters, and delay generation using interrupts	**04**	**LO2**
III	**Interfacing Peripherals with Microcontrollers**	Interfacing push buttons, LEDs, LCD, and 7-segment displays. Analog-to-Digital Conversion (ADC) and Digital-to-Analog Conversion (DAC). Stepper and DC motor control using PWM	**04**	**LO3**

IV	**Communication Protocols (UART, SPI, I2C)**	Serial communication using UART, I2C, SPI, and RS-485. Wireless communication using Zigbee, Wi-Fi, and Bluetooth. Data transmission and reception between microcontrollers	**04**	**LO4**
V	**IoT-Based Microcontroller Applications**	IoT fundamentals and cloud connectivity using ESP32. MQTT communication for real-time IoT automation. Smart home automation using Wi-Fi-based microcontrollers	**04**	**LO5**
VI	**Real-Time Projects and Case Studies**	Industrial applications: PLC vs. Microcontrollers. Robotics applications using microcontrollers. Design and development of an automation-based final project	**04**	**LO6**

Text Books:

1. "Microprocessor Architecture, Programming, and Applications with 8085" – Ramesh Gaonkar
2. "The 8051 Microcontroller and Embedded Systems" – Muhammad Ali Mazidi, Janice Mazidi
3. "PIC Microcontroller and Embedded Systems" – Muhammad Ali Mazidi, Rolin McKinlay
4. "Embedded Systems: Real-Time Operating Systems for ARM Cortex-M" – Jonathan W. Valvano

References:

1. "AVR Microcontroller and Embedded Systems" – Muhammad Ali Mazidi, Sarmad Naimi
2. "ARM System Developer's Guide" – Andrew Sloss
3. "Embedded Systems: Architecture, Programming, and Design" – Raj Kamal
4. "Programming Embedded Systems in C and C++" – Michael Barr

Online Resources:

Website Name
1. Coursera – "Embedded Systems – Shape the World" (University of Texas at Austin) https://www.coursera.org/learn/embedded-systems 2. MIT OpenCourseWare – "Embedded Systems" https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/ 3. NPTEL – "Microcontrollers and Embedded Systems" https://nptel.ac.in/courses/108/105/108105102/ 4. ESP32 Official Documentation

https://docs.espressif.com/projects/esp-idf/en/latest/esp32/

5. Arduino Reference
   https://www.arduino.cc/reference/en/

List of Experiments.

Sr No	List of Experiments	Hrs
01	Basic arithmetic operations (Addition, Subtraction, Multiplication, Division) using 8085/8086 Assembly Language.	02
02	Register operations using 8051 Embedded C programming.	02
03	LED blinking using 8051 and ESP32 (delay using timers).	02
04	Generating a square wave using a microcontroller timer.	02
05	Display characters on 16x2 LCD using 8051.	02
06	Interfacing a DC motor and controlling speed using PWM.	02
07	Data transfer between two microcontrollers using UART.	02
08	Interfacing EEPROM using I2C.	02
09	Uploading sensor data to Firebase using ESP32.	02
10	Remote LED control via MQTT protocol.	02
11	Home automation project using relays and ESP32.	02
12	Smart irrigation system using soil moisture sensors and IoT.	02

Sr No	List of Assignments / Tutorials	Hrs
01	• Write an assembly language program for a simple looping and branching operation. • Study the instruction set and prepare a comparison table for different microcontrollers.	02

02	• Write a program for multi-bit port manipulation in embedded C. • Study the compiler optimization techniques for microcontroller code.	02
03	• Write a PWM-based motor control program using embedded C. • Study and implement an ADC sensor reading using a microcontroller.	02
04	• Write an I2C communication program to read sensor data. • Study the MODBUS protocol used in industrial automation.	02
05	• Create a simple IoT-based temperature monitoring system. • Study the security challenges in IoT-based microcontroller applications.	02
06	• Design a traffic light control system using microcontrollers. • Compare RTOS-based embedded system development with non-RTOS solutions.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL 103	Process Control & Instrumentation Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL103	Process Control & Instrumentation Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To introduce fundamental concepts of process control and instrumentation.
2. To familiarize students with different sensors, transducers, and measurement techniques.
3. To develop practical knowledge of control system components like controllers, actuators, and final control elements.
4. To enhance analytical skills in designing and tuning controllers such as PID.
5. To provide hands-on experience with industrial process control systems.
6. To bridge the gap between theoretical concepts and real-world applications in process industries.

Lab Outcomes:

Upon completing this lab, students will be able to:

1. Understand the working principles of various process control instruments.
2. Calibrate and test different types of sensors and transducers.
3. Design and implement PID controllers for process applications.
4. Analyze control responses for different processes and improve system performance.
5. Develop skills in data acquisition and control using industry-standard software/hardware.
6. Apply knowledge of instrumentation and control in industrial automation and process industries.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basics of IoT	02	
I	**Fundamentals of Process Control**	Basics of process variables (temperature, pressure, flow, level, etc.). Introduction to process control loops. Open-loop vs. closed-loop control	**04**	**LO1**
II	**Sensors and Transducers**	Measurement principles: Resistance Temperature Detector (RTD), Thermocouple, Level Sensors, etc. Calibration of sensors and signal conditioning. Static and dynamic characteristics of instruments	**04**	**LO2**
III	**Controllers and Control Elements**	Proportional, Integral, and Derivative (PID) control. Tuning of controllers (Ziegler–Nichols method, Cohen-Coon method). Final control elements: Pneumatic and electrical actuators, control valves	**04**	**LO3**
IV	**Process Control Applications**	Level control system. Flow control system. Temperature control system.	**04**	**LO4**
V	**Data Acquisition and Industrial Automation**	Data acquisition systems (DAQ). Introduction to PLCs, SCADA, and DCS systems. Industrial control applications	**04**	**LO5**
VI	**Advanced Topics in Instrumentation**	Smart sensors and IoT in instrumentation. Industrial case studies. Safety and reliability in instrumentation	**04**	**LO6**

Text Books:

1. B. G. Liptak, *Instrument Engineers' Handbook: Process Control*, CRC Press.
2. D. Patranabis, *Principles of Industrial Instrumentation*, Tata McGraw Hill.
3. C. D. Johnson, *Process Control Instrumentation Technology*, Pearson.
4. P. Harriott, *Process Control*, Tata McGraw Hill.

References:

1. S. K. Singh, *Industrial Instrumentation & Control*, Tata McGraw Hill.
2. G. Stephanopoulos, *Chemical Process Control: An Introduction to Theory and Practice*, Prentice Hall.
3. E. A. Parr, *Industrial Control Handbook*, Industrial Press.
4. W. Bolton, *Instrumentation and Control Systems*, Newnes.

Online Resources:

Website Name
1. MIT OpenCourseWare – https://ocw.mit.edu 2. NI (National Instruments) Tutorials – https://www.ni.com/en-us/innovations.html 3. Coursera: Process Control & Instrumentation Courses – https://www.coursera.org 4. NPTEL (IIT Lectures on Instrumentation & Control) – https://nptel.ac.in/courses/ 5. Control Engineering Online – https://www.controleng.com 6. ISA (International Society of Automation) – https://www.isa.org

List of Experiments.

Sr No	List of Experiments	Hrs
01	Calibration of a pressure sensor and pressure transmitter.	02
02	Measurement of temperature using RTD and thermocouple.	02
03	Calibration of a flow sensor (Orifice meter, Venturi meter).	02
04	Level measurement using different level sensors.	02
05	PID controller tuning using MATLAB/SCADA.	02
06	Characteristics of a control valve and determination of valve coefficient.	02
07	Implementation of ON/OFF, P, PI, and PID control using hardware setup.	02
08	Study and simulation of a control system using LabVIEW/MATLAB.	02
09	Data acquisition using DAQ system.	02
10	PLC-based industrial automation experiment (Basic programming using ladder logic).	02

Sr No	List of Assignments / Tutorials	Hrs

01	Design and analysis of an electronic temperature control system.	02
02	Simulating and analyzing the response of a first-order and second-order system.	02
03	Comparative study of different PID tuning methods.	02
04	Industrial case study on process control implementation.	02
05	Designing a control loop for a distillation column or heat exchanger.	02
06	Research paper review on recent trends in process control instrumentation.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAVECL101	Programming Techniques Laboratory	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAVECL101	Programming Techniques Laboratory	--	--	--	--	50	--	50

Lab Objectives:

1. To introduce fundamental programming concepts and problem-solving techniques.
2. To develop proficiency in structured, modular, and object-oriented programming approaches.
3. To enhance logical thinking and debugging skills through hands-on programming.
4. To familiarize students with data structures, algorithms, and their applications.
5. To provide experience in file handling, memory management, and error handling.
6. To introduce advanced programming concepts such as multithreading, recursion, and dynamic memory allocation.

Lab Outcomes:

Upon completion of this lab, students will be able to:

1. Apply fundamental programming concepts to solve real-world problems.
2. Implement structured and object-oriented programming techniques efficiently.
3. Develop, test, and debug programs using appropriate development tools.
4. Use data structures and algorithms for problem-solving.
5. Implement file handling, memory management, and exception handling techniques.
6. Design and develop efficient and optimized code for computational problems.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Fundamentals of Programming.	02	
I	**Fundamentals of Programming**	Introduction to programming languages (C/Python/Java). Variables, data types, and operators. Input/output operations Control structures: Conditional and looping statements	**04**	**LO1**
II	**Functions and Modular Programming**	User-defined functions and recursion. Scope of variables and storage classes. Function overloading and inline functions (C++/Java). Modular programming concepts	**04**	**LO2**
III	**Arrays, Pointers, and Strings**	One-dimensional and multi-dimensional arrays. Strings and string manipulation functions. Pointers and dynamic memory allocation. Pointer arithmetic and pointer to functions	**04**	**LO3**
IV	**Object-Oriented Programming (OOP) Concepts**	Classes and objects. Constructor and destructor. Inheritance and polymorphism. Operator overloading and function overriding	**04**	**LO4**
V	**Data Structures and Algorithms**	Stacks and Queues (Implementation using Arrays and Linked Lists). Searching and Sorting algorithms (Linear, Binary Search, Bubble Sort, Merge Sort, etc.). Linked Lists (Singly, Doubly, and Circular Linked Lists). Trees and Graphs (Basic operations and traversals)	**04**	**LO5**
VI	**File Handling and Advanced Topics**	File operations: Read, write, append, and update. Exception handling and error handling techniques. Multithreading concepts. Database connectivity	**04**	**LO6**

Text Books:

1. E. Balagurusamy, *Programming in ANSI C*, McGraw Hill.
2. Herbert Schildt, *C++: The Complete Reference*, McGraw Hill.
3. Robert Lafore, *Object-Oriented Programming in C++*, Pearson.
4. Yashavant Kanetkar, *Let Us C*, BPB Publications.

References:

1. Brian W. Kernighan & Dennis M. Ritchie, *The C Programming Language*, Prentice Hall.
2. E. Balagurusamy, *Object-Oriented Programming with C++*, McGraw Hill.
3. Bjarne Stroustrup, *The C++ Programming Language*, Addison-Wesley.
4. Mark Lutz, *Learning Python*, O'Reilly Media.

Online Resources:

Website Name
1. GeeksforGeeks – https://www.geeksforgeeks.org 2. W3Schools – https://www.w3schools.com 3. TutorialsPoint – https://www.tutorialspoint.com 4. NPTEL (IIT Online Courses) – https://nptel.ac.in/courses 5. Codecademy – https://www.codecademy.com 6. Coursera: Programming Fundamentals – https://www.coursera.org

List of Experiments.

Sr No	List of Experiments	Hrs
01	Implement basic arithmetic operations using a programming language.	02
02	Develop programs using decision-making and looping constructs.	02
03	Write functions for mathematical computations (factorial, Fibonacci series, etc.).	02
04	Implement arrays for searching and sorting operations.	02
05	Develop programs using pointers and dynamic memory allocation.	02
06	Implement classes and objects using OOP concepts.	02
07	Demonstrate inheritance and polymorphism in object-oriented programming.	02

08	Implement stack and queue operations using arrays and linked lists.	02
09	Implement searching and sorting algorithms.	02
10	Perform file handling operations such as reading, writing, and updating files.	02
11	Implement exception handling mechanisms in C++/Java/Python.	02
12	Develop multithreading applications using Java/Python.	02

Sr No	List of Assignments / Tutorials	Hrs
01	Implement a simple calculator using functions and switch-case.	02
02	Develop a program to find the largest and smallest elements in an array.	02
03	Write a program to implement string operations (concatenation, comparison, etc.).	02
04	Implement a program for matrix multiplication using dynamic memory allocation.	02
05	Develop a mini project using object-oriented programming concepts.	02
06	Implement data structures (stacks, queues, linked lists) with real-world applications.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 4 assignments.

Term Work Marks: 50 Marks (Total marks) = 30 Marks (Experiment) + 15 Marks (Assignments) + 5 Marks (Attendance)

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE1011	Artificial Intelligence and Expert Systems in Automation	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE1011	Artificial Intelligence and Expert Systems in Automation	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course provides an in-depth understanding of Artificial Intelligence (AI) and Expert Systems in industrial automation. It covers AI techniques, knowledge representation, reasoning, machine learning, and expert systems for decision-making. The course emphasizes real-world applications, including predictive maintenance, process optimization, and industrial robotics. Students will learn to design and implement AI-driven solutions for intelligent automation in industries.

Course Objectives:

1. To introduce the fundamental concepts of Artificial Intelligence and Expert Systems in automation.
2. To develop knowledge of machine learning, deep learning, and rule-based systems for industrial applications.
3. To familiarize students with knowledge representation, reasoning, and inference techniques.
4. To explore AI applications in robotics, process control, and decision-making in automation.
5. To integrate AI models with industrial automation tools like SCADA, PLC, and IoT.
6. To analyze real-world AI-driven automation systems and their impact on efficiency and productivity.

Course Outcomes:

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

1. Understand AI techniques and their role in automation systems.

2. Apply machine learning and expert system methodologies to industrial automation.
3. Develop and implement AI-based solutions for decision-making and process optimization.
4. Integrate AI models with industrial control systems such as SCADA and PLC.
5. Analyze case studies of AI applications in robotics, predictive maintenance, and quality control.
6. Evaluate ethical, safety, and reliability concerns in AI-driven automation.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of Programming.	**2**	--
I	**Introduction to AI in Automation**	Fundamentals of Artificial Intelligence (AI) and its applications in automation. AI vs. conventional automation systems Role of AI in industrial processes and smart manufacturing	**6**	**CO1**
II	**Knowledge Representation and Expert Systems**	Knowledge-based systems and expert systems. Knowledge representation techniques: Semantic networks, frames, and ontologies. Rule-based systems, inference mechanisms, and decision trees.	**7**	**CO2**
III	**Machine Learning and Deep Learning in Automation**	Supervised, unsupervised, and reinforcement learning. Neural networks and deep learning for predictive maintenance. AI models for process control and optimization	**7**	**CO3**
IV	**AI in Industrial Robotics and Process Control**	AI-based motion planning and control in robotics. Computer vision and AI-powered quality inspection. AI applications in predictive maintenance and fault detection.	**6**	**CO4**
V	**Integration of AI with Automation Systems**	AI in SCADA, PLC, and IoT-based automation. Industrial case studies on AI-driven automation. AI-powered digital twins and smart manufacturing systems	**7**	**CO5**
VI	**Ethical, Safety, and Future Trends in AI Automation**	Challenges of AI implementation in industries. Safety, reliability, and ethical considerations in AI-based	**4**	**CO6**

		automation. Future trends: Edge AI, cloud-based automation, and Industry 4.0		

Text Books:

1. Stuart Russell & Peter Norvig, *Artificial Intelligence: A Modern Approach*, Pearson.
2. Elaine Rich & Kevin Knight, *Artificial Intelligence*, McGraw-Hill.
3. Dan W. Patterson, *Introduction to Artificial Intelligence and Expert Systems*, Pearson.
4. S. Rajasekaran & G. A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*, Prentice Hall.

References:

1. Nils J. Nilsson, *Artificial Intelligence: A New Synthesis*, Morgan Kaufmann.
2. John Durkin, *Expert Systems: Principles and Programming*, Cengage Learning.
3. Kevin Warwick, *Artificial Intelligence: The Basics*, Routledge.
4. Padhmapriya, *Artificial Intelligence in Industrial Automation*, Wiley.

Online References:

Website Name
1. MIT OpenCourseWare – Artificial Intelligence – https://ocw.mit.edu 2. Coursera – AI for Everyone by Andrew Ng – https://www.coursera.org 3. Google AI Blog – https://ai.googleblog.com 4. NPTEL AI and Machine Learning Courses – https://nptel.ac.in/courses 5. Towards Data Science (Medium AI Articles) – https://towardsdatascience.com 6. IEEE Xplore – Research papers on AI in Automation – https://ieeexplore.ieee.org

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

- A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL1011	Artificial Intelligence and Expert Systems in Automation Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL1011	Artificial Intelligence and Expert Systems in Automation Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To introduce fundamental concepts of Artificial Intelligence (AI) and Expert Systems in automation.
2. To develop practical knowledge of AI techniques used in industrial automation.
3. To provide hands-on experience in programming AI-based automation solutions.
4. To familiarize students with expert systems, rule-based systems, and decision-making algorithms.
5. To implement machine learning and deep learning techniques for automation tasks.
6. To bridge the gap between theoretical AI models and real-world industrial applications.

Lab Outcomes:

Upon completing this lab, students will be able to:

1. Apply AI techniques in solving industrial automation problems.
2. Develop intelligent systems using rule-based and knowledge-based approaches.
3. Implement machine learning algorithms for predictive maintenance and automation.
4. Design and deploy expert systems for decision-making in industrial applications.
5. Integrate AI-based models with automation hardware and software systems.
6. Analyze case studies and real-world applications of AI and expert systems in industrial environments.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of AI	02	
I	**Introduction to AI and Expert Systems in Automation**	Basics of Artificial Intelligence (AI) and Expert Systems. AI applications in industrial automation. Role of AI in robotics, process control, and decision-making	**04**	**LO1**
II	**Knowledge Representation and Reasoning**	Knowledge-based systems and rule-based inference. Logical reasoning and decision trees. Fuzzy logic and uncertainty handling in expert systems.	**04**	**LO2**
III	**Machine Learning in Automation**	Introduction to machine learning (supervised, unsupervised, and reinforcement learning). Regression and classification techniques for industrial data. Neural networks and deep learning applications in automation	**04**	**LO3**
IV	**Expert Systems Development**	Architecture of an expert system. Rule-based expert systems using Prolog/Python. Case studies on expert systems in fault detection and predictive maintenance	**04**	**LO4**
V	**AI in Robotics and Industrial Automation**	AI techniques in industrial robotics Path planning and optimization using AI algorithms. AI-powered vision systems for quality inspection	**04**	**LO5**

VI	**Integration of AI with Automation Tools**	AI in SCADA and PLC systems. Cloud-based AI automation solutions. Ethical considerations and future trends in AI-driven automation.	**04**	**LO6**

Text Books:

1. Stuart Russell & Peter Norvig, *Artificial Intelligence: A Modern Approach*, Pearson.
2. Elaine Rich & Kevin Knight, *Artificial Intelligence*, McGraw-Hill.
3. S. Rajasekaran & G. A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*, Prentice Hall.
4. Dan W. Patterson, *Introduction to Artificial Intelligence and Expert Systems*, Pearson.

References:

1. Nils J. Nilsson, *Artificial Intelligence: A New Synthesis*, Morgan Kaufmann.
2. Padhmapriya, *Artificial Intelligence in Industrial Automation*, Wiley.
3. John Durkin, *Expert Systems: Principles and Programming*, Cengage Learning.
4. Kevin Warwick, *Artificial Intelligence: The Basics*, Routledge.

Online Resources:

Website Name
1. MIT OpenCourseWare – Artificial Intelligence – https://ocw.mit.edu 2. Coursera – AI for Everyone by Andrew Ng – https://www.coursera.org 3. Google AI Blog – https://ai.googleblog.com 4. NPTEL AI and Machine Learning Courses – https://nptel.ac.in/courses 5. Towards Data Science (Medium AI Articles) – https://towardsdatascience.com 6. IEEE Xplore – Research papers on AI in Automation – https://ieeexplore.ieee.org

List of Experiments.

Sr No	List of Experiments	Hrs
01	Implement basic search algorithms (BFS, DFS) in AI-based control systems.	02
02	Develop a simple rule-based expert system using Prolog/Python.	02
03	Design and implement a fuzzy logic-based control system for an industrial process.	02
04	Apply machine learning algorithms for predictive maintenance in industrial systems.	02

05	Implement a neural network model for process control and optimization.	02
06	Develop an AI-powered image recognition system for automated quality control.	02
07	Implement reinforcement learning for optimizing an industrial process.	02
08	AI-based chatbot for troubleshooting industrial issues.	02
09	Integration of AI with PLC and SCADA for real-time monitoring.	02
10	Case study analysis of AI-driven automation in industries.	02

Sr No	List of Assignments / Tutorials	Hrs
01	Write a report on the role of AI in industrial automation.	02
02	Implement a decision tree classifier for fault detection in industrial systems.	02
03	Develop an AI-based recommendation system for industrial process optimization.	02
04	Research and analyze an industrial case study where AI improved efficiency.	02
05	Design a small-scale AI-powered robotic system for automation.	02
06	Implement a hybrid AI model (rule-based + machine learning) for industrial decision-making.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE1012	Digital Image Processing and Computer vision	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE1012	Digital Image Processing and Computer vision	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course covers the fundamental concepts, techniques, and applications of Digital Image Processing (DIP) and Computer Vision (CV). It provides insights into image enhancement, transformation, feature extraction, segmentation, and object recognition. Students will learn various image processing algorithms and develop skills in designing computer vision applications using machine learning and deep learning techniques. The course also explores real-world applications such as medical imaging, robotics, biometrics, and autonomous systems**.**

Course Objectives:

1. To understand the fundamentals of digital image processing and computer vision.
2. To explore image enhancement, restoration, and compression techniques.
3. To study various feature extraction and segmentation methods used in image analysis.
4. To implement object detection and recognition algorithms in computer vision.
5. To develop practical skills using computer vision libraries and tools like OpenCV, MATLAB, or Python.
6. To analyze real-world applications of DIP and CV in fields like biometrics, medical imaging, and automation.

Course Outcomes:

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

1. Understand digital image formation, representation, and processing techniques.
2. Apply image enhancement and restoration techniques to improve image quality.
3. Implement feature extraction and segmentation methods for image analysis.
4. Design and develop object recognition and classification models.
5. Use computer vision libraries such as OpenCV, TensorFlow, and MATLAB for image processing.
6. Develop real-time computer vision applications in medical imaging, security, and automation.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basics of image processing.	**2**	--
I	**Introduction to Digital Image Processing and Computer Vision**	Introduction to Digital Image Processing (DIP). Image representation: Pixels, resolution, and color models. Introduction to Computer Vision and its applications. Image formation, sensing, and digitization	**6**	**CO1**
II	**Image Enhancement and Restoration**	Spatial domain and frequency domain techniques. Histogram equalization and contrast enhancement. Noise removal using filtering techniques (Gaussian, Median, Bilateral). Image restoration and deblurring	**7**	**CO2**
III	**Image Segmentation and Feature Extraction**	Edge detection (Sobel, Canny, Laplacian). Thresholding techniques (Otsu's method, adaptive thresholding). Region-based segmentation (Watershed algorithm). Feature extraction techniques (HOG, SIFT, SURF)	**7**	**CO3**
IV	**Object Detection and Recognition**	Template matching and pattern recognition. Introduction to machine learning and deep learning in computer vision. Object detection using Haar cascades, YOLO, and SSD. Face detection and recognition techniques	**6**	**CO4**

V	**Motion Analysis and 3D Vision**	Optical flow and motion tracking. Stereo vision and depth estimation. Structure from motion (SfM) and 3D reconstruction. Gesture recognition and activity recognition	**7**	**CO5**
VI	**Applications and Future Trends in Computer Vision**	Medical imaging and biomedical applications. Computer vision in autonomous systems and robotics. Industrial inspection and quality control. Ethics, privacy, and challenges in computer vision.	**4**	**CO6**

Text Books:

1. Rafael C. Gonzalez & Richard E. Woods, *Digital Image Processing*, Pearson.
2. S. Jayaraman, S. Esakkirajan & T. Veerakumar, *Digital Image Processing*, McGraw Hill.
3. Sonka, Hlavac & Boyle, *Image Processing, Analysis, and Machine Vision*, Cengage Learning.
4. David A. Forsyth & Jean Ponce, *Computer Vision: A Modern Approach*, Pearson.

References:

1. Bernd Jähne, *Digital Image Processing*, Springer.
2. Mark Nixon & Alberto Aguado, *Feature Extraction and Image Processing for Computer Vision*, Academic Press.
3. Simon Prince, *Computer Vision: Models, Learning, and Inference*, Cambridge University Press.
4. Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer.

Online References:

Website Name
1. OpenCV Documentation – https://docs.opencv.org 2. Coursera – Computer Vision Courses – https://www.coursera.org 3. MIT OpenCourseWare – Image Processing & Computer Vision – https://ocw.mit.edu 4. GeeksforGeeks – Image Processing & Computer Vision – https://www.geeksforgeeks.org 5. Kaggle – Computer Vision Datasets & Projects – https://www.kaggle.com 6. Towards Data Science – Computer Vision Articles – https://towardsdatascience.com

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL1012	Digital Image Processing and Computer vision Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL1012	Digital Image Processing and Computer vision Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide hands-on experience in fundamental image processing techniques.
2. To develop proficiency in image enhancement, segmentation, and filtering methods.
3. To implement and analyze various feature extraction techniques used in computer vision.
4. To design and develop object detection and recognition algorithms using machine learning and deep learning.
5. To apply computer vision techniques in real-world applications such as medical imaging, surveillance, and automation.
6. To familiarize students with OpenCV, MATLAB, and Python-based image processing libraries.

Lab Outcomes:

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

1. Perform basic image processing operations such as filtering, transformation, and enhancement.
2. Apply image segmentation and feature extraction techniques to real-world datasets.
3. Implement object detection and recognition using machine learning models.
4. Work with motion tracking and 3D vision techniques for computer vision applications.

5. Develop and deploy computer vision models using OpenCV, TensorFlow, and MATLAB.
6. Analyze and evaluate the effectiveness of computer vision algorithms in industrial and medical applications.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of Image processing.	02	
I	**Introduction to Image Processing and OpenCV**	Understanding image representation and manipulation. Loading, displaying, and saving images using OpenCV and MATLAB. Basic operations: Grayscale conversion, resizing, and color space transformations	**04**	**LO1**
II	**Image Enhancement and Filtering**	Histogram equalization and contrast stretching. Smoothing and sharpening filters (Gaussian, Median, Laplacian). Edge detection using Sobel, Prewitt, and Canny filters	**04**	**LO2**
III	**Image Segmentation and Feature Extraction**	Thresholding techniques: Otsu's method, Adaptive thresholding. Morphological operations: Erosion, dilation, opening, and closing. Feature extraction using HOG, SIFT, SURF, and ORB	**04**	**LO3**
IV	**Object Detection and Recognition**	Template matching and pattern recognition. Face detection using Haar cascades and Deep Learning models. Object recognition using YOLO, SSD, and Faster R-CNN	**04**	**LO4**
V	**Motion Analysis and 3D Vision**	Optical flow tracking (Lucas-Kanade, Farneback). Background subtraction techniques for motion detection. Stereo vision and depth estimation using disparity mapping	**04**	**LO5**
VI	**Real-World Applications and Project Work**	Computer vision in medical imaging, surveillance, and autonomous vehicles. AI-based gesture recognition and facial	**04**	**LO6**

		expression analysis. Final project: Developing an end-to-end computer vision system		

Text Books:

1. Rafael C. Gonzalez & Richard E. Woods, *Digital Image Processing*, Pearson.
2. Sonka, Hlavac & Boyle, *Image Processing, Analysis, and Machine Vision*, Cengage Learning.
3. David A. Forsyth & Jean Ponce, *Computer Vision: A Modern Approach*, Pearson.
4. Adrian Kaehler & Gary Bradski, *Learning OpenCV 3: Computer Vision in C++ with the OpenCV Library*, O'Reilly.

References:

1. Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer.
2. Mark Nixon & Alberto Aguado, *Feature Extraction and Image Processing for Computer Vision*, Academic Press.
3. Simon Prince, *Computer Vision: Models, Learning, and Inference*, Cambridge University Press.
4. Deep Learning for Computer Vision with Python, *PyImageSearch* (Adrian Rosebrock).

Online Resources:

Website Name
1. OpenCV Documentation – **https://docs.opencv.org** **2.** Coursera – Deep Learning Specialization (Computer Vision) – **https://www.coursera.org** **3.** MIT OpenCourseWare – Image Processing & Computer Vision – **https://ocw.mit.edu** **4.** GeeksforGeeks – Digital Image Processing – **https://www.geeksforgeeks.org** **5.** Kaggle – Computer Vision Datasets & Projects – **https://www.kaggle.com** 6. Towards Data Science – Computer Vision Articles – **https://towardsdatascience.com**

List of Experiments.

Sr No	List of Experiments	Hrs
01	Image Loading and Displaying: Read, write, and manipulate images in OpenCV and MATLAB.	02

02	Histogram Equalization and Enhancement: Implement contrast stretching and histogram modification techniques.	02
03	Edge Detection and Feature Extraction: Apply Canny edge detection and extract features using SIFT/SURF.	02
04	Image Segmentation: Implement thresholding, region-based segmentation, and morphological operations.	02
05	Object Detection: Perform face detection using Haar cascades and deep learning models.	02
06	Motion Detection and Tracking: Implement background subtraction and optical flow tracking.	02
07	Stereo Vision and Depth Estimation: Work with disparity maps for 3D vision.	02
08	Object Recognition with Machine Learning: Train a classifier (SVM, CNN) for image classification tasks.	02
09	Real-Time Video Processing: Apply computer vision techniques on live video feeds.	02
10	Project Implementation: Develop a real-world computer vision application	02

Sr No	List of Assignments / Tutorials	Hrs
01	Report on Image Processing Techniques: Analyze and compare different image enhancement methods.	02
02	Implementation of Edge Detection Algorithms: Compare the results of different edge detection filters.	02
03	Feature Extraction Analysis: Implement and analyze HOG, SIFT, and ORB descriptors.	02
04	Object Detection and Tracking: Develop an application that tracks an object in real-time video.	02
05	Face Recognition System: Implement face recognition using OpenCV and deep learning.	02
06	Final Project: Design and implement a real-world computer vision application based on current research trends.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE1013	Mechatronic Devices and Systems	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE1013	Mechatronic Devices and Systems	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course provides an in-depth understanding of Mechatronic Systems, integrating mechanical, electrical, electronic, and computer engineering principles. It covers the design, modeling, and control of mechatronic devices, emphasizing sensors, actuators, control systems, and embedded programming**.** The

course also explores applications in robotics, automation, and intelligent manufacturing.

Course Objectives:

1. To introduce the fundamental principles of mechatronic systems and their applications.
2. To study the integration of mechanical, electrical, electronic, and software components.
3. To develop knowledge of sensors, actuators, and control systems in mechatronics.
4. To apply microcontrollers, PLCs, and embedded systems for automation.
5. To analyze the modeling and simulation of mechatronic devices.
6. To explore real-world applications in robotics, automotive systems, and industrial automation.

Course Outcomes:

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

1. Understand the principles of mechatronic system design and integration.
2. Apply sensor technologies and actuators for system automation.
3. Develop control strategies using microcontrollers, PLCs, and embedded systems.
4. Model and simulate mechatronic devices for real-world applications.
5. Implement signal processing and feedback control techniques in mechatronic systems.
6. Evaluate and troubleshoot intelligent automation systems in industrial applications.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basics of electronics and mechanicals.	**2**	--
I	**Introduction to Mechatronic Systems**	Definition and scope of Mechatronics. Key components: Sensors, Actuators, Controllers, and Interfaces. Applications in automotive, aerospace, manufacturing, and robotics	**6**	**CO1**
II	**Sensors and Signal Processing**	Types of sensors: Position, Velocity, Force, Temperature, Proximity. Data acquisition and signal conditioning. Analog vs. digital sensors, interfacing techniques	**7**	**CO2**
III	**Actuators and Motion Control**	Types of actuators: Pneumatic, Hydraulic, and Electric Actuators. Stepper motors and Servo motors.	**7**	**CO3**

		PID control for motion systems		
IV	**Microcontrollers and Embedded Systems in Mechatronics**	Introduction to Microcontrollers (Arduino, PIC, ARM). PLC programming and industrial automation. Communication protocols: I2C, SPI, UART, CAN	**6**	**CO4**
V	**Modeling, Simulation, and System Integration**	Mathematical modeling of Mechatronic Systems. Simulation tools: MATLAB/Simulink, LabVIEW. Integration of mechanical and electronic systems	**7**	**CO5**
VI	**Applications and Future Trends in Mechatronics**	Autonomous Vehicles, Robotics, and Smart Factories. AI-driven Mechatronics and Digital Twins. Challenges and Innovations in Industry 4.0	**4**	**CO6**

Text Books:

1. W. Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, Pearson.
2. David G. Alciatore & Michael B. Histand, *Introduction to Mechatronics and Measurement Systems*, McGraw Hill.
3. Devdas Shetty & Richard A. Kolk, *Mechatronics System Design*, Cengage Learning.
4. John R. Hackworth & Frederick D. Hackworth, *Programmable Logic Controllers: Programming Methods and Applications*, Pearson.

References:

1. Clarence W. de Silva, *Mechatronics: A Foundation Course*, CRC Press.
2. Bishop Robert H., *The Mechatronics Handbook*, CRC Press.
3. Mohamed Rafiquzzaman, *Microcontroller Theory and Applications*, Wiley.
4. Rolf Isermann, *Mechatronic Systems: Fundamentals*, Springer.

Online References:

Website Name
1. MIT OpenCourseWare – Mechatronics Courses – https://ocw.mit.edu 2. Coursera – Mechatronics and Automation Courses – https://www.coursera.org 3. IEEE Xplore – Research papers on Mechatronics – https://ieeexplore.ieee.org 4. Mechatronics and Robotics Articles (Towards Data Science) – https://towardsdatascience.com 5. National Instruments – LabVIEW and Mechatronics – https://www.ni.com 6. • Arduino and Raspberry Pi Projects for Mechatronics – https://www.arduino.cc

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL1013	Mechatronic Devices and Systems lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL 1013	Mechatronic Devices and Systems lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide hands-on experience with mechatronic components, sensors, and actuators.
2. To develop skills in microcontroller programming and interfacing for automation.
3. To analyze and implement motion control and PID control systems.
4. To integrate mechanical, electrical, and software components for system automation.
5. To design and develop embedded systems and PLC-based control applications.
6. To explore real-world applications of mechatronics in robotics, automotive, and industrial automation.

Lab Outcomes:

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

1. Demonstrate proficiency in sensor interfacing and signal processing techniques.
2. Implement actuation and motion control using servo motors, stepper motors, and DC motors.
3. Develop microcontroller-based embedded systems for automation.
4. Apply Programmable Logic Controllers (PLCs) for industrial control applications.
5. Simulate and test mechatronic systems using MATLAB/Simulink and LabVIEW.
6. Design a mechatronic system prototype for real-world applications in robotics, automation, or IoT.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of IoT sensors.	02	
I	**Introduction to Mechatronics and Sensors**	Overview of mechatronic systems and applications. Sensor types and interfacing (IR, Ultrasonic, Temperature, Force, Proximity). Data acquisition and signal processing techniques	**04**	**LO1**
II	**Actuators and Motion Control**	DC motors, Servo motors, Stepper motors: Working principles and control. Motor drivers and interfacing with Arduino, PIC, and Raspberry Pi. Implementation of PWM control and PID controllers	**04**	**LO2**
III	**Microcontrollers and Embedded Systems**	Introduction to Arduino, PIC, and ARM-based controllers. Analog and digital I/O operations. Interfacing sensors, actuators, and	**04**	**LO3**

		communication modules (I2C, SPI, UART, CAN)		
IV	**PLC Programming and Industrial Automation**	Basics of PLC architecture and ladder logic programming. Implementing simple automation sequences (Conveyor belt, Traffic Light, Bottle Filling). Industrial control applications using HMI and SCADA	**04**	**LO4**
V	**Modeling, Simulation, and System Integration**	Mathematical modeling of mechatronic systems. Simulation using MATLAB/Simulink and LabVIEW. Case studies: Automotive mechatronics, Smart Home Automation	**04**	**LO5**
VI	**Project Work and Future Trends**	Application-based projects in robotics, IoT, and industrial automation. AI and Machine Learning applications in Mechatronics. Ethics, challenges, and innovations in Industry 4.0	**04**	**LO6**

Text Books:

1. W. Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, Pearson.
2. David G. Alciatore & Michael B. Histand, *Introduction to Mechatronics and Measurement Systems*, McGraw Hill.
3. Devdas Shetty & Richard A. Kolk, *Mechatronics System Design*, Cengage Learning.
4. John R. Hackworth & Frederick D. Hackworth, *Programmable Logic Controllers: Programming Methods and Applications*, Pearson.

References:

1. Clarence W. de Silva, *Mechatronics: A Foundation Course*, CRC Press.
2. Bishop Robert H., *The Mechatronics Handbook*, CRC Press.
3. Mohamed Rafiquzzaman, *Microcontroller Theory and Applications*, Wiley.
4. Rolf Isermann, *Mechatronic Systems: Fundamentals*, Springer.

Online Resources:

Website Name
1. MIT OpenCourseWare – Mechatronics Courses – https://ocw.mit.edu 2. Coursera – Mechatronics and Automation Courses – https://www.coursera.org 3. IEEE Xplore – Research papers on Mechatronics – https://ieeexplore.ieee.org 4. Mechatronics and Robotics Articles (Towards Data Science) –

https://towardsdatascience.com
5. National Instruments – LabVIEW and Mechatronics – https://www.ni.com
6. Arduino and Raspberry Pi Projects for Mechatronics – https://www.arduino.cc
7. PLCs and Industrial Automation Tutorials – https://www.plcacademy.com

List of Experiments.

Sr No	List of Experiments	Hrs
01	Sensor Interfacing: Read data from temperature, IR, and ultrasonic sensors using Arduino.	02
02	Motor Control: Implement PWM speed control for DC motors, stepper motors, and servo motors.	02
03	PID Controller Implementation: Design a PID control system for speed or position control.	02
04	Microcontroller-Based Automation: Develop a light automation or security system using sensors and microcontrollers.	02
05	PLC-Based Industrial Control: Implement a conveyor belt control system using PLCs.	02
06	Communication Protocols in Mechatronics: Implement I2C and SPI-based sensor communication	02
07	Data Logging and IoT Integration: Send sensor data to a cloud server (Thingspeak, Firebase).	02
08	Simulation of a Mechatronic System: Model and **simulate** motion control or a robotic arm in MATLAB.	02
09	HMI & SCADA in Industrial Automation: Create an HMI-based industrial monitoring system.	02
10	Project Implementation: Develop a real-world mechatronic prototype (robot, automated system, or IoT-based device).	02

Sr No	List of Assignments / Tutorials	Hrs

01	Report on Mechatronic System Components: Analysis of real-world mechatronic devices.	02
02	Simulation of a PID Control System: Implement and analyze the performance of a PID controller.	02
03	PLC-Based Automation Case Study: Research and analyze a PLC-based industrial application.	02
04	Microcontroller-Based Sensor Integration**:** Develop a real-time sensor-based monitoring system.	02
05	MATLAB/Simulink Simulation Project: Model and simulate a robotic or motion control system**.**	02
06	Final Project: Design and implement a fully functional mechatronic system for an industry-relevant application.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC201	Automation System Design	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC201	Automation System Design	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Automation System Design focuses on the principles, methods, and tools required to develop efficient and intelligent automation systems. The course covers system modeling, control strategies, sensors, actuators, PLC programming, industrial communication, and emerging trends such as Industry 4.0 and AI-driven automation. Students will gain practical insights into automated system design, implementation, and optimization across industries.

Course Objectives:

1. To understand the fundamental concepts of automation and system design.
2. To explore various sensors, actuators, and controllers used in automation systems.
3. To develop skills in PLC programming and industrial control strategies.
4. To analyze automation system integration using industrial communication protocols.
5. To evaluate design considerations for reliability, safety, and efficiency in automation.
6. To introduce emerging trends such as IoT, Industry 4.0, and AI in automation.

Course Outcomes:

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

1. Explain the fundamentals of automation system design and its industrial applications.
2. Select appropriate sensors, actuators, and controllers for specific automation needs.
3. Design and implement PLC-based control systems for automation processes.
4. Integrate automation systems using SCADA, HMI, and industrial networking protocols.
5. Optimize automation systems considering performance, cost, and safety aspects.

6. Apply Industry 4.0 concepts, including AI, IoT, and smart automation strategies.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of automation and system design.	**2**	--
I	**Introduction to Automation System Design**	Definition, importance, and applications of automation. Types of automation: Fixed, Programmable, and Flexible. Components of an automation system: Sensors, Actuators, Controllers, and Communication Networks. Automation strategies: Open-loop vs. Closed-loop control. Case studies on industrial automation applications.	**6**	**CO1**
II	**Sensors, Actuators & Control Elements**	Classification of sensors and transducers: Temperature, Pressure, Proximity, Optical, and Motion Sensors. Selection criteria and calibration of sensors for automation applications. Actuators: Hydraulic, Pneumatic, and Electric Actuation Systems. Stepper and Servo motors: Working principles and applications. PID control and tuning methods.	**7**	**CO2**
III	**Programmable Logic Controllers (PLCs) & Industrial Controllers**	Introduction to PLCs: Architecture, working principles, and types. PLC Programming languages: Ladder Logic, Functional Block, and Structured Text. Interfacing sensors and actuators with PLCs. Timers, counters, and logic functions in PLC programming. Real-world PLC applications: Conveyor belt systems, Automated sorting, and Assembly lines.	**7**	**CO3**
IV	**Industrial Communication & SCADA Systems**	Overview of industrial communication protocols: RS232, RS485, Modbus, CAN, Profibus, Ethernet/IP. Introduction to Supervisory Control and Data Acquisition (SCADA).	**6**	**CO4**

		SCADA system components: RTUs, MTUs, Communication Networks. Human-Machine Interface (HMI): Design and Implementation. IoT-based remote monitoring and control		
V	**Design Considerations & Safety in Automation**	System reliability, maintainability, and fault diagnostics. Safety standards in automation: ISO 13849, IEC 61508. Risk assessment techniques for automation systems. Energy efficiency and sustainability in automation. Case studies on automation failures and safety improvements.	**7**	**CO5**
VI	**Advanced Automation & Industry 4.0**	Introduction to Industry 4.0 & Smart Manufacturing. Role of Artificial Intelligence (AI) and Machine Learning in automation. Cyber- Physical Systems (CPS) and Digital Twin in automation. Cloud computing, IoT, and Big Data applications in automation. Future trends in automation and smart factories	**4**	**CO6**

Text Books:

1. Mikell P. Groover, *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson.
2. Frank D. Petruzella, *Programmable Logic Controllers*, McGraw-Hill.
3. D. Patranabis, *Principles of Industrial Instrumentation*, Tata McGraw-Hill.
4. William Bolton, *Programmable Logic Controllers*, Elsevier.

References:

1. John W. Webb & Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications*, Pearson.
2. Hugh Jack, *Automating Manufacturing Systems with PLCs*, Lulu.
3. David Bailey & Edwin Wright, *Practical SCADA for Industry*, Elsevier.
4. Stuart A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, ISA.
5. Wolfgang Kuhn, *Industrial Communication Technology Handbook*, CRC Press.

Online References:

Website Name
1. MIT OpenCourseWare – Automation & Control Systems – https://ocw.mit.edu 2. Coursera – Industrial Automation & PLC Programming – https://www.coursera.org 3. ISA (International Society of Automation) Resources – https://www.isa.org 4. Siemens Automation Training & Resources – https://www.siemens.com/automation 5. Rockwell Automation Learning Portal – https://www.rockwellautomation.com 6. • ABB Industrial Automation Solutions – https://new.abb.com/automation

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC202	Industrial Automation	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC202	Industrial Automation	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course covers the fundamentals, components, and applications of industrial automation in manufacturing, process industries, and smart factories. Students will learn about automation technologies such as sensors, actuators, PLCs, SCADA, robotics, and Industry 4.0**,** focusing on system integration, control strategies, and optimization techniques. Practical case studies and hands-on experience with industrial automation tools will be emphasized.

Course Objectives:

1. To introduce the fundamental concepts and significance of industrial automation.
2. To study sensors, actuators, and controllers used in automated systems.
3. To develop expertise in PLC programming and industrial control techniques.
4. To understand SCADA, HMI, and industrial communication networks.
5. To analyze robotics, motion control, and AI-based automation applications.
6. To explore Industry 4.0, IoT, and cybersecurity in modern industrial automation.

Course Outcomes:

After completing this course, students will be able to:

1. Describe the role of automation in industrial applications and its benefits.
2. Select appropriate sensors, actuators, and control systems for various automation tasks.
3. Design and program PLC-based control systems for industrial applications.
4. Implement SCADA and HMI for real-time industrial process monitoring and control.
5. Integrate robotics and motion control solutions in automated systems.
6. Apply Industry 4.0 principles, AI, and IoT for smart automation and cybersecurity.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of IoT	**2**	--
I	**Introduction to Industrial Automation**	Definition, need, and benefits of automation. Types of industrial automation: Fixed, Programmable, and Flexible Automation. Components of an automation system: Sensors, Actuators, Controllers, and Communication Networks. Introduction to Control Strategies: Open-loop vs. Closed-loop Control. Case Studies of Industrial Automation in Manufacturing and Process Industries.	**6**	**CO1**
II	**Sensors, Actuators & Industrial Control Systems**	Classification of sensors: Proximity, Temperature, Pressure, Optical, Ultrasonic, Vibration. Selection criteria and signal conditioning for industrial sensors. Types of actuators: Pneumatic, Hydraulic, Electric Actuators. Stepper and Servo motors: Working principle, control strategies, and applications. PID Control Systems: Tuning methods and implementation in automation	**7**	**CO2**
III	**Programmable Logic Controllers (PLCs) & Automation Programming**	Introduction to PLCs: Architecture, working principles, input/output modules. PLC Programming languages: Ladder Diagram (LD), Functional Block Diagram (FBD), Structured Text (ST). Timers, Counters, Arithmetic & Logical Operations in PLC programming Interfacing sensors and actuators with PLCs. PLC-based case studies: Conveyor control, Bottle	**7**	**CO3**

		filling, Traffic light control		
IV	**Industrial Communication, SCADA & HMI**	Industrial Communication Protocols: Modbus, Profibus, CAN Bus, EtherNet/IP. Introduction to SCADA systems: Architecture, Components, and Applications. HMI (Human-Machine Interface): Design and Implementation. Data Acquisition, Real-time Monitoring & Control using SCADA. SCADA-based case studies: Water treatment plant, Power distribution system	**6**	**CO4**
V	**Robotics & Motion Control in Automation**	Introduction to Industrial Robotics: Components, Types, and Applications. Robot Kinematics and Programming. Motion Control Systems: Servo Drives, Encoders, Motor Controllers. Collaborative Robots (Cobots) and AI-based Robotics. Case Studies on Robotics in Manufacturing and Logistics.	**7**	**CO5**
VI	**Industry 4.0, IoT & Cybersecurity in Automation**	Introduction to Industry 4.0 and Smart Manufacturing. IoT in Industrial Automation: Cloud-based Monitoring, Predictive Maintenance. Digital Twin Technology in Automation. Cybersecurity Challenges in Industrial Automation. Future Trends in Industrial Automation: AI, ML, and Blockchain Applications	**4**	**CO6**

Text Books:

1. Mikell P. Groover, *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson.
2. Frank D. Petruzella, *Programmable Logic Controllers*, McGraw-Hill.
3. D. Patranabis, *Principles of Industrial Instrumentation*, Tata McGraw-Hill.
4. William Bolton, *Programmable Logic Controllers*, Elsevier.

References:

1. John W. Webb & Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications*, Pearson.
2. Hugh Jack, *Automating Manufacturing Systems with PLCs*, Lulu.
3. David Bailey & Edwin Wright, *Practical SCADA for Industry*, Elsevier.
4. Stuart A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, ISA.
5. Wolfgang Kuhn, *Industrial Communication Technology Handbook*, CRC Press.
6.

Online References:

Website Name
1. MIT OpenCourseWare – Automation & Control Systems – https://ocw.mit.edu 2. Coursera – Industrial Automation & PLC Programming – https://www.coursera.org 3. ISA (International Society of Automation) Resources – https://www.isa.org 4. Siemens Automation Training & Resources – https://www.siemens.com/automation 5. Rockwell Automation Learning Portal – https://www.rockwellautomation.com 6. ABB Industrial Automation Solutions – https://new.abb.com/automation

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

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End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC203	Industrial Internet of Things	**3**	**-**	**-**	**3**	**-**	**-**	**3**

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC203	Industrial Internet of Things	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

The Industrial Internet of Things (IIoT) course provides a comprehensive understanding of connected industrial systems, smart manufacturing, and data-driven automation**.** It covers IIoT architecture, industrial protocols, sensors, edge computing, cloud platforms, cybersecurity, and analytics**.** The course focuses on real-world applications of IIoT in industries such as manufacturing, energy, healthcare, and logistics**.**

Course Objectives:

1. To introduce IIoT fundamentals, architecture, and key technologies.
2. To study sensors, actuators, and industrial communication protocols used in IIoT.
3. To explore edge computing, cloud platforms, and real-time data processing.
4. To understand cybersecurity challenges and best practices in IIoT.
5. To analyze data analytics, AI, and predictive maintenance in IIoT applications.
6. To examine real-world case studies of IIoT implementation in smart industries.

Course Outcomes:

After completing this course, students will be able to:

1. Explain IIoT architecture, components, and industry applications.
2. Select appropriate sensors, actuators, and communication protocols for industrial automation.
3. Implement edge computing and cloud-based IIoT solutions for real-time monitoring.
4. Apply cybersecurity measures to protect industrial IoT networks.
5. Use AI and machine learning for predictive maintenance and optimization.
6. Analyze case studies and design IIoT-based smart industrial systems.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of IoT	**2**	--
I	**Introduction to Industrial Internet of Things (IIoT)**	Definition, Scope, and Evolution of IIoT. Difference between IoT and IIoT. IIoT System Architecture: Sensors, Edge Devices, Cloud, Analytics. Applications of IIoT: Smart Manufacturing, Energy, Healthcare, Logistics. Challenges and Future Trends in IIoT.	**6**	**CO1**
II	**IIoT Sensors, Actuators & Communication Protocols**	Types of Industrial Sensors: Temperature, Pressure, Proximity, Vibration, Optical. Industrial Actuators: Motors, Valves, Relays, Pneumatic Systems. Communication Protocols in IIoT:Wired: RS232, RS485, Modbus, Profibus, CAN Bus. Wireless: Zigbee, LoRa, Wi-Fi, BLE, 5G. Industrial Ethernet & OPC-UA. Data Acquisition and Signal Processing in IIoT	**7**	**CO2**
III	**Edge Computing, Cloud Computing & IIoT Platforms**	Introduction to Edge Computing: Edge vs. Cloud Computing. Edge AI & Edge Analytics for real-time decision-making. Cloud Platforms for IIoT: AWS IoT, Microsoft Azure IoT, Google Cloud IoT. Data Storage, Processing, and	**7**	**CO3**

		Management in IIoT. Fog Computing and Hybrid Cloud Models		
IV	**Cybersecurity in Industrial IoT**	IIoT Security Challenges & Risks: Cyberattacks, Data Breaches, Ransomware. Security Frameworks & Standards: IEC 62443, NIST, ISO 27001. Authentication & Encryption Techniques for IIoT Networks. Secure Device Management & Identity Access Control. Case Studies on IIoT Cybersecurity Attacks & Prevention Strategies	**6**	**CO4**
V	**Data Analytics, AI & Machine Learning in IIoT**	Introduction to Industrial Data Analytics & Predictive Maintenance. Machine Learning Algorithms for IIoT: Anomaly Detection, Predictive Modeling. Digital Twin Technology & Simulation in Smart Factories. AI-based Industrial Process Optimization & Energy Efficiency. Case Studies on AI-driven IIoT Implementations	**7**	**CO5**
VI	**IIoT Applications & Industry 4.0 Integration**	IIoT in Smart Manufacturing: Robotics, Smart Sensors, Automation. IIoT in Smart Grids & Energy Management. IIoT in Healthcare & Medical Device Monitoring. IIoT in Logistics & Supply Chain Optimization. Emerging Technologies in IIoT: Blockchain, 5G, Quantum Computing	**4**	**CO6**

Text Books:

1. Alasdair Gilchrist, *Industry 4.0: The Industrial Internet of Things*, Apress.
2. Olivier Hersent, David Boswarthick, Omar Elloumi, *The Internet of Things: Key Applications and Protocols*, Wiley.
3. Arvind Ravulavaru, *Hands-on Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0*, Packt Publishing.
4. Rajkumar Buyya & Amir Vahid Dastjerdi, *Internet of Things: Principles and Paradigms*, Morgan Kaufmann.

References:

1. Sudip Misra, Anandarup Mukherjee, Arijit Roy, *Introduction to Industrial Internet of Things and Industry 4.0*, CRC Press.
2. Dietmar P.F. Möller, Roland E. Haas, *Guide to Industrial Internet of Things (IIoT): AI, Analytics, and Security*, Springer.
3. Gupta B.K., *Industrial Internet of Things (IIoT): Principles and Applications*, Springer.
4. Vlad Moca, Robert Ioan Ciobanu, *Industrial IoT Design and Applications*, Wiley.
5. John Davies, Carsten Maple, *Cybersecurity for Industrial Control Systems and IIoT*, Springer.

Online References:

Website Name
1. MIT OpenCourseWare – IoT & Industrial Automation – https://ocw.mit.edu 2. Coursera – Industrial IoT & Industry 4.0 Courses – https://www.coursera.org 3. IBM Watson IoT Learning Hub – https://www.ibm.com/cloud/internet-of-things 4. Microsoft Azure IoT Resources – https://azure.microsoft.com/en-us/solutions/iot/ 5. NIST Cybersecurity Guidelines for IIoT – https://www.nist.gov 6. Siemens Industrial IoT Solutions – https://www.siemens.com/iiot

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAOJT 201	Internship/Field Project	Entire Semester			4	-	-	4

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAOJT201	Internship/Field Project	--	--	--	--	--	100	100	200

Internship Guidelines for M.Tech Courses

1. Introduction The internship program is an integral part of the M.Tech curriculum designed to provide students with industry exposure and practical experience. This document outlines the guidelines for successful completion of the internship.

2. Objectives

- To bridge the gap between academic learning and industry practices.
- To enhance students' technical and professional skills.
- To provide hands-on experience in real-world applications of engineering concepts.
- To enable students to work on live projects and improve problem-solving abilities.

3. Eligibility

- Students must have completed at least one semester of the M.Tech program.
- Internship opportunities must be relevant to the student’s area of specialization.
- Internship will be full-time time offline mode in the Industry.

4. Duration

- The internship should be at least **15 weeks** and a **maximum of one full semester**.
- The duration may vary based on the institution's academic calendar and industry requirements.

5. Selection Process

- Students may apply through the college placement cell or approach companies independently.
- Approval from the department’s HoD and internship coordinator is required before starting the internship.

- Department HoD must assign a department faculty member for monitoring of the internship and time-to-time update of task and attendance in coordination with the student and the industry.

6. Internship Activities

- Students should be involved in research, development, analysis, and project work.
- Periodic evaluations and reports should be submitted as per university norms.

7. Supervision & Mentorship

- Each student will have an **academic M.E. Guide (faculty mentor) as allocated by the department HoD** and an **industry mentor**.
- Regular interactions with mentors must be maintained to ensure progress.

8. Documentation & Reporting

- A formal offer and appointment letter from the organization is required.
- Students must maintain a daily/weekly log/project diary of activities and progress.
- The department will conduct two reviews as per the University of Mumbai guidelines.
- A **mid-term review** and a **final internship report** must be submitted.
- Presentation and viva-voce may be conducted based on university of Mumbai policies.

9. Evaluation Criteria

- Internship performance will be evaluated based on:
    - **Work contribution & learning outcomes** (40%)
    - **Mid-term & final reports** (30%)
    - **Presentation & viva-voce** (30%)

10. Code of Conduct

- Students must adhere to the professional and ethical standards of the organization.
- Confidentiality agreements, if any, must be strictly followed.
- Any misconduct may lead to termination of the internship and academic penalties.

11. Certification & Credit Allocation

- Upon successful completion, students must obtain a completion certificate from the organization.
- Internship credits will be awarded as per university regulations.

12. Important Deadlines

- Submission of internship proposal and offer letter of Internship: One Week before the Semester Start to the college department.
- Mid-term evaluation: Two review need to be conducted by the department: 1st review in 2nd week after semester start and then 2nd review between 8th to 10th week of the semester.
- Final report submission: as per term work submission date of UoM.
- Viva-voce & presentation: as per UoM policies.

For above details, students should consult their department's internship coordinator.

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 100 Marks (Total marks) = 70 Marks (Internship) + 25 Marks (Report) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above internship.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL 201	Automation System Design Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL201	Automation System Design Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide hands-on experience in designing and implementing automation systems.
2. To familiarize students with PLC, SCADA, and industrial automation tools.
3. To implement real-time process control using sensors, actuators, and controllers.
4. To develop programming skills for industrial control systems.
5. To integrate various automation technologies such as IoT and robotics.
6. To analyze and optimize automation solutions for efficiency and reliability.

Lab Outcomes:

Upon completion of this lab, students will be able to:

1. Design and implement automation solutions using PLC and SCADA.

2. Develop industrial control logic for automated processes.
3. Interface sensors, actuators, and industrial communication protocols.
4. Simulate and test automation systems in a controlled environment.
5. Analyze the efficiency of automation systems and suggest improvements.
6. Work with advanced automation technologies such as IoT and AI-based control.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic Programming Skills	02	
I	**Introduction to Industrial Automation & Lab Setup**	Overview of industrial automation components (PLCs, SCADA, HMIs, Sensors, Actuators). Understanding different industrial communication protocols (Modbus, Profibus, Ethernet/IP). Safety procedures and laboratory protocols	**04**	**LO1**
II	**PLC Programming & Ladder Logic Implementation**	Basics of PLC architecture and operation. Introduction to ladder logic programming. Implementation of combinational and sequential control logic.	**04**	**LO2**
III	**Process Control & SCADA Integration**	Overview of SCADA systems and real-time monitoring. Creating graphical interfaces for process visualization. Data acquisition and logging in SCADA.	**04**	**LO3**
IV	**Sensor & Actuator Interfacing for Automation**	Types of sensors (Proximity, Temperature, Pressure, Flow, Vision Sensors). Actuator control using industrial automation systems. Sensor calibration and integration with controllers	**04**	**LO4**
V	**Industrial Robotics & IoT-based Automation**	Introduction to industrial robots and programming basics. IoT-enabled smart automation systems. Remote monitoring and predictive maintenance using IoT	**04**	**LO5**
VI	**Case Studies & Industrial Applications**	Real-world industrial automation applications. Optimization of automated manufacturing systems Future trends in automation and	**04**	**LO6**

		Industry 4.0		

Text Books:

1. "Programmable Logic Controllers: Principles and Applications" – John W. Webb, Ronald A. Reis
2. "Industrial Automation: Hands-On" – Frank Lamb
3. "SCADA and Me: A Beginner's Guide" – Stuart A. Boyer
4. "Introduction to Robotics: Mechanics and Control" – John J. Craig

References:

1. "Industrial Automation and Robotics" – A. K. Gupta, S. K. Arora
2. "Programmable Automation Technologies" – Daniel Kandray
3. "Mechatronics: Principles and Applications" – Godfrey C. Onwubolu
4. "Artificial Intelligence for Robotics" – Francis X. Govers

Online Resources:

Website Name
1. PLC Tutorials - Automation Direct – Online PLC and SCADA tutorials. 2. IEEE Xplore – Research papers on industrial automation. 3. MIT OpenCourseWare - Automation & Control – Free automation learning resources. 4. Coursera - Industrial Automation – Online courses on PLC, SCADA, and IoT in automation.

List of Experiments.

Sr No	List of Experiments	Hrs
01	Identification and study of PLC, SCADA, and industrial sensors.	02
02	Configuring and testing industrial communication networks.	02
03	Writing and executing a basic PLC program using a simulator.	02
04	Implementing logic gates and timers using ladder logic.	02
05	Developing a simple SCADA interface for motor speed control.	02
06	Implementing data acquisition and trend analysis in SCADA.	02

07	Interfacing temperature and proximity sensors with a PLC.	02
08	Controlling a pneumatic actuator using PLC and relay logic.	02
09	Programming a robotic arm for pick-and-place applications.	02
10	Developing an IoT-based automation project for smart manufacturing.	02
11	Case study analysis of an automated production line.	02
12	Optimizing an automation process using AI-based predictive control.	02

Sr No	List of Assignments / Tutorials	Hrs
01	Design and simulate a PLC-based conveyor belt system.	02
02	Develop a SCADA application for monitoring industrial processes.	02
03	Implement a PID control system in an automation setup.	02
04	Analyze an industrial IoT case study and develop a report.	02
05	Write a research paper on AI and ML in industrial automation.	02
06	Design an industrial automation project integrating multiple technologies.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL 202	Industrial Automation Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL202	Industrial Automation Lab	--	--	--	--	25	25	50

Lab Objectives: Students will be able:

1. To provide hands-on experience with industrial automation technologies.
2. To familiarize students with PLC, SCADA, and industrial communication protocols.
3. To develop skills in programming and implementing automation solutions.
4. To integrate various sensors, actuators, and controllers in industrial systems.
5. To explore the role of IoT and AI in modern industrial automation.
6. To analyze and optimize automation processes for industrial applications.

Lab Outcomes:

Upon completion of this lab, students will be able to:

1. Implement PLC programming and SCADA-based industrial control systems.
2. Develop automation logic using ladder logic, function block, and structured text.
3. Interface sensors, actuators, and communication networks in industrial automation.
4. Simulate and test automation solutions using software tools.
5. Evaluate and optimize automated industrial systems.
6. Explore advancements in IoT, AI, and robotics for industrial automation.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of C Programming.	02	
I	**Introduction to Industrial Automation & Safety Protocols**	Overview of industrial automation components. Introduction to PLC, SCADA, HMI, DCS. Safety standards and industrial protocols (Modbus, Profibus, Ethernet/IP)	**04**	**LO1**
II	**PLC Programming & Ladder Logic Implementation**	Understanding PLC hardware and software. Programming PLC using Ladder Logic. Implementing combinational and sequential control	**04**	**LO2**
III	**SCADA System Development & Process Control**	Basics of SCADA systems and real-time data monitoring. HMI design for industrial automation. Data logging and trend analysis	**04**	**LO3**
IV	**Sensor & Actuator Integration in Automation**	Working with industrial sensors (Proximity, Pressure, Temperature, Flow). Actuator control (Servo, Pneumatics, Hydraulics). Calibration and integration with PLC/SCADA	**04**	**LO4**
V	**Industrial Robotics & IoT-based Automation**	Basics of industrial robots and programming. IoT in automation – remote monitoring & predictive maintenance. Edge computing and cloud integration for industrial automation	**04**	**LO5**
VI	**Case Studies & Industry Applications**	Smart factories and Industry 4.0. AI-driven predictive maintenance. Optimization of manufacturing systems.	**04**	**LO6**

Text Books:

1. "Programmable Logic Controllers: Principles and Applications" – John W. Webb, Ronald A. Reis
2. "Industrial Automation: Hands-On" – Frank Lamb

3. "SCADA: Supervisory Control and Data Acquisition" – Stuart A. Boyer
4. "Robotics in Industrial Automation" – Richard Shell

References:

1. "Industrial Automation and Robotics" – A. K. Gupta, S. K. Arora
2. "Mechatronics: Principles and Applications" – Godfrey C. Onwubolu
3. "Introduction to Industrial Internet of Things (IIoT)" – Alasdair Gilchrist
4. "Artificial Intelligence for Industrial Automation" – Peter Norvig, Stuart Russell

Online Resources:

- PLC Tutorials - Automation Direct – Online PLC and SCADA tutorials.
- IEEE Xplore – Research papers on industrial automation.
- MIT OpenCourseWare - Automation & Control – Free automation learning resources.
- Coursera - Industrial Automation – Online courses on PLC, SCADA, and IoT in automation.

List of Experiments.

Sr No	List of Experiments	Hrs
01	Identification and study of industrial automation components.	02
02	Configuring an industrial communication network.	02
03	Writing and executing a basic PLC program using timers and counters.	02
04	Implementing a motor control circuit using ladder logic.	02
05	Developing a SCADA system for real-time temperature monitoring.	02
06	Implementing an HMI-based industrial control system.	02
07	Interfacing a temperature sensor with a PLC for closed-loop control.	02
08	Controlling a pneumatic actuator using PLC logic.	02
09	Programming a robotic arm for pick-and-place operations.	02
10	Implementing an IoT-based real-time industrial automation system.	02
11	Case study analysis of an automated production line.	02
12	Optimizing an automation process using AI-driven control strategies.	02

Sr No	List of Assignments / Tutorials	Hrs
01	Design and simulate a PLC-based conveyor belt system.	02
02	Develop a SCADA system for process control and monitoring.	02
03	Implement PID control for an industrial automation application.	02
04	Create an IoT-based predictive maintenance system for industrial equipment.	02
05	Study and document an industrial automation case study.	02
06	Develop a project integrating PLC, SCADA, and IoT for smart manufacturing.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL 203	Industrial Internet of Things Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL203	Industrial Internet of Things Lab	--	--	--	--	25	25	50

Lab Objectives: Students will be able:

1. To understand the fundamental concepts and architecture of Industrial IoT (IIoT).
2. To provide hands-on experience in implementing IIoT-based solutions for industrial applications.
3. To explore various sensors, actuators, and industrial communication protocols.
4. To integrate IIoT platforms with cloud computing, edge computing, and data analytics.
5. To develop real-time monitoring and control systems using IoT devices.
6. To analyze security, reliability, and optimization techniques in IIoT systems.

Lab Outcomes:

Upon completion of this lab, students will be able to:

1. Set up IIoT devices and establish industrial connectivity.
2. Implement data acquisition and communication using industrial protocols.
3. Develop cloud-based IIoT applications for industrial automation.
4. Design predictive maintenance solutions using AI and machine learning.
5. Analyze cybersecurity risks in IIoT systems and implement security measures.
6. Optimize IIoT networks for scalability, efficiency, and real-time processing.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of IoT.	02	
I	**Introduction to IIoT & Industrial Networking**	Overview of IIoT architecture and components. Industrial communication protocols (MQTT, OPC UA, Modbus, Profibus). Setting up IIoT network architecture.	**04**	**LO1**
II	**Sensor & Actuator Interfacing in IIoT Systems**	Sensor selection for industrial applications. Interfacing actuators for real-time control. Wireless sensor networks (WSN) and IoT gateways.	**04**	**LO2**
III	**Cloud Integration & Data Analytics in IIoT**	Cloud computing for IIoT applications (AWS, Azure, Google Cloud). Real-time data logging, analytics, and visualization. Edge computing for real-time industrial applications.	**04**	**LO3**
IV	**AI & Machine Learning for IIoT-Based Predictive Maintenance**	Basics of AI/ML in industrial applications. Developing predictive maintenance models. Deploying ML models on edge devices.	**04**	**LO4**
V	**IIoT Cybersecurity & Secure Data Transmission**	IIoT security threats and countermeasures. Implementing authentication and encryption in IIoT networks. Role of blockchain in IIoT security.	**04**	**LO5**
VI	**Case Studies & Industry Applications**	Smart factories and Industry 4.0 implementation. IIoT applications in smart grids, logistics, and healthcare. Optimization of industrial automation using IIoT	**04**	**LO6**

Text Books:

1. "Industrial IoT: Challenges, Design Principles, Applications, and Security" – Geng Wu, Douglas D. Reynolds
2. "Internet of Things: Principles and Paradigms" – Rajkumar Buyya, Amir Vahid Dastjerdi
3. "IoT and Edge Computing for Architects" – Perry Lea
4. "Hands-On Industrial Internet of Things: Create a Smart Industrial IoT System Using Edge Analytics and Digital Twins" – Giacomo Veneri

References:

1. "Industrial Internet of Things: Technologies and Research Directions" – Anand Nayyar, Akshi Kumar
2. "Industrial IoT for Engineers and Programmers" – Sabri Arik
3. "Machine Learning for IoT: Intelligent IoT Systems" – Shyam Varan Nath
4. "IoT Security: Practical Guide to Securing Connected Devices" – Brian Russell, Drew Van Duren

Online Resources:

1. IIoT Tutorials - IoT for Industry – Industrial IoT tutorials and case studies.
2. MIT OpenCourseWare - Industrial IoT – Free IIoT learning resources.
3. Coursera - Industrial IoT – Online courses on IIoT and automation.
4. IEEE Xplore – Research papers on IIoT applications and technologies.

List of Experiments.

Sr No	List of Experiments	Hrs
01	Setting up an IIoT testbed using Raspberry Pi/Arduino and industrial sensors.	02
02	Implementing MQTT-based communication between IIoT devices and a cloud server.	02
03	Interfacing temperature, pressure, and vibration sensors with an IIoT gateway.	02
04	Controlling industrial actuators using IIoT-based remote control.	02
05	Connecting IIoT devices to an AWS IoT Core instance for cloud monitoring.	02
06	Implementing real-time data visualization using Grafana and InfluxDB.	02
07	Implementing anomaly detection in industrial equipment using ML models.	02
08	Deploying an edge computing-based predictive maintenance solution.	02
09	Implementing secure communication between IIoT devices using TLS/SSL encryption.	02
10	Securing IIoT data transmission using blockchain-based authentication.	02
11.	Case study analysis of IIoT-based industrial automation systems.	02
12.	Developing a small-scale IIoT project integrating multiple technologies.	02

Course	Course Name	Teaching Scheme	Credits Assigned

Sr No	List of Assignments / Tutorials	Hrs
01	Design a real-time IIoT-based monitoring system for an industrial plant.	02
02	Implement an AI-based predictive maintenance model for industrial machinery.	02
03	Develop a cloud-based dashboard for IIoT data visualization and analytics.	02
04	Study and document IIoT security risks and mitigation strategies.	02
05	Research on the role of edge computing in IIoT and submit a technical report.	02
06	Develop a prototype IIoT project integrating sensor data, cloud analytics, and AI.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Code		(Contact Hours)						
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE2011	Swarm Intelligence	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE2011	Swarm Intelligence	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Swarm Intelligence (SI) is a nature-inspired computational approach that focuses on the collective behavior of decentralized, self-organized systems, such as ant colonies, bird flocks, and fish schools**.** This course explores various swarm intelligence algorithms, including Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), Firefly Algorithm, and more**.** It emphasizes their applications in optimization, robotics, artificial intelligence, and complex problem-solving**.**

Course Objectives:

1. To introduce the fundamental concepts and principles of Swarm Intelligence.
2. To study various swarm intelligence-based algorithms and their inspirations from nature.
3. To analyze the mathematical models and optimization techniques used in SI.
4. To explore the applications of SI in engineering, robotics, AI, and real-world problem-solving.
5. To compare and contrast different swarm intelligence algorithms and their performance.
6. To implement SI-based optimization techniques in practical computational problems.

Course Outcomes:

After completing this course, students will be able to:

1. Explain the key principles of Swarm Intelligence and its biological foundations.
2. Apply different swarm-based algorithms for optimization and decision-making.
3. Design and implement swarm intelligence algorithms for real-world problems.
4. Analyze and compare the efficiency of SI techniques in different domains.
5. Integrate swarm intelligence concepts into AI, robotics, and automation systems.
6. Develop innovative solutions using SI techniques in complex problem-solving scenarios.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of AI and Python.	**2**	--
I	**Introduction to Swarm Intelligence**	Definition, Characteristics, and Self-Organizing Systems. Biological Inspiration: Ant Colonies, Bird Flocks, Fish Schools, Bees, and Fireflies. Comparison with Traditional AI and Optimization Algorithms. Emergence and Decentralized Control in SI. Applications of Swarm Intelligence: Optimization, Robotics, Scheduling, and Decision Making	**6**	**CO1**
II	**Particle Swarm Optimization (PSO)**	Concept of PSO: Social and Cognitive Behavior of Particles. Mathematical Model of PSO: Velocity and Position Update Equations. Variants of PSO: Constriction Coefficients, Adaptive PSO, Multi-objective PSO. Hybrid PSO Techniques. Applications of PSO: Function Optimization, Neural Network Training, Image Processing	**7**	**CO2**
III	**Ant Colony Optimization (ACO) & Artificial Bee Colony (ABC) Algorithms**	Ant Colony Optimization (ACO): Pheromone Trail Formation, Stigmergy, and Path Optimization. Variants of ACO: Max-Min ACO, Rank-Based ACO, Elitist ACO. Applications: Traveling Salesman Problem (TSP), Network Routing, Scheduling. Artificial Bee Colony (ABC) Algorithm: Foraging Behavior of Honey Bees. Phases of ABC: Employed Bees, Onlooker Bees, and Scout Bees. Applications: Feature Selection, Function Optimization, Clustering	**7**	**CO3**

IV	**Firefly Algorithm, Bat Algorithm, and Other SI Techniques**	Firefly Algorithm: Bioluminescence Mechanism and Attraction Rules. Bat Algorithm: Echolocation Behavior and Frequency-Based Search. Cuckoo Search Algorithm: Nesting Strategy and Levy Flight Mechanism. Differential Evolution (DE) and Glowworm Swarm Optimization (GSO). Comparative Analysis of SI Techniques	**6**	**CO4**
V	**Applications of Swarm Intelligence in Robotics & AI**	Swarm Robotics: Behavior Coordination, Flocking, Obstacle Avoidance. Swarm-based Control in Multi-Agent Systems. Application in Artificial Neural Networks and Deep Learning. Swarm Intelligence in Healthcare, Finance, and Cybersecurity. Real-World Case Studies on SI Applications.	**7**	**CO5**
VI	**Advanced Topics in Swarm Intelligence & Future Trends**	Hybrid Swarm Intelligence Models. Quantum Swarm Intelligence (QSI). Deep Reinforcement Learning with SI. SI in Smart Cities and Internet of Things (IoT). Ethical Considerations and Limitations of SI. Future Directions of Swarm Intelligence in AI and Robotics	**4**	**CO6**

Text Books:

1. James Kennedy & Russell C. Eberhart, *Swarm Intelligence*, Morgan Kaufmann.
2. Marco Dorigo & Thomas Stützle, *Ant Colony Optimization*, MIT Press.
3. Xin-She Yang, *Nature-Inspired Optimization Algorithms*, Elsevier.
4. Eric Bonabeau, Marco Dorigo, & Guy Théraulaz, *Swarm Intelligence: From Natural to Artificial Systems*, Oxford University Press.

References:

1. Andries P. Engelbrecht, *Computational Intelligence: An Introduction*, Wiley.

2. Xin-She Yang, *Firefly Algorithm and Swarm Intelligence: Theory and Applications*, Springer.
3. Kevin M. Passino, *Biomimicry for Optimization, Control, and Automation*, Springer.
4. Christian Blum & Daniel Merkle, *Swarm Intelligence: Introduction and Applications*, Springer.
5. Ali Minai & Dan Braha, *Complex Engineered Systems: Science Meets Technology*, Springer.

Online References:

Website Name
1. MIT OpenCourseWare – Swarm Intelligence & AI – https://ocw.mit.edu 2. Coursera – Swarm Intelligence & Evolutionary Computing – https://www.coursera.org 3. IEEE Computational Intelligence Society – https://cis.ieee.org 4. Swarm Intelligence Research Papers (Springer, Elsevier, ACM) – https://www.springer.com 5. Arxiv.org – Open Access Papers on Swarm Intelligence – https://arxiv.org 6. GitHub – Open-Source Swarm Intelligence Projects – https://github.com

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE2012	Optimization Algorithms	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE2012	Optimization Algorithms	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

The course "Optimization Algorithms" focuses on methods and techniques to solve optimization problems efficiently. Optimization is the process of finding the best solution to a problem within a defined set of constraints. This course introduces both classical and modern optimization algorithms, their theoretical foundation, and practical applications. By the end of the course, students will have a solid understanding of optimization methods used in engineering, economics, machine learning, and various real-world applications.

Course Objectives:

1. To understand the basic concepts and terminologies in optimization theory.
2. To learn and apply classical optimization methods, such as linear programming and convex optimization.
3. To study advanced optimization techniques, including evolutionary algorithms and metaheuristics.
4. To analyze the efficiency of various optimization algorithms in solving real-world problems.
5. To learn the implementation of optimization algorithms using software tools.
6. To explore optimization in multi-objective and dynamic environments.

Course Outcomes:

1. Understand and apply optimization methods to practical engineering and real-world problems.
2. Identify suitable optimization techniques for various types of problems, including constrained, unconstrained, linear, and nonlinear problems.
3. Develop proficiency in implementing optimization algorithms such as Genetic Algorithms, Simulated Annealing, and Particle Swarm Optimization.
4. Solve multi-objective optimization problems and analyze trade-offs between conflicting objectives.
5. Conduct computational experiments and interpret results in terms of solution quality and computational efficiency.
6. Demonstrate the ability to evaluate and fine-tune optimization models for real-time applications.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of algorithms.	**2**	--
I	**Introduction to Optimization**	Definition and types of optimization problems. Objective function, constraints, and optimization variables. Classification of optimization problems (linear vs. nonlinear, constrained vs. unconstrained). Optimization problem formulation. Examples of real-world optimization problems	**6**	**CO1**
II	**Classical Optimization Techniques**	Linear programming and Simplex method. Unconstrained optimization methods (Gradient Descent, Newton's method). Constrained optimization (Karush-Kuhn-Tucker conditions, Lagrange multipliers). Quadratic programming. Convex optimization.	**7**	**CO2**
III	**Metaheuristic Optimization Algorithms**	Introduction to metaheuristics and their applications. Genetic Algorithm (GA): selection, crossover, mutation, and fitness function. Simulated Annealing	**7**	**CO3**

		(SA). Particle Swarm Optimization (PSO). Ant Colony Optimization (ACO). Differential Evolution (DE)		
IV	**Multi-objective Optimization**	Concept of multi-objective optimization. Pareto efficiency and trade-offs between conflicting objectives. Techniques for solving multi-objective optimization problems: Weighted Sum Method, ε-constraint method, Pareto-based algorithms. Multi-objective Genetic Algorithm (MOGA). NSGA-II (Non-dominated Sorting Genetic Algorithm)	**6**	**CO4**
V	**Optimization in Dynamic and Stochastic Environments**	Dynamic optimization problems and challenges. Stochastic optimization techniques. Adaptive and learning-based optimization algorithms. Online optimization and real-time decision-making Applications in robotics, AI, and machine learning	**7**	**CO5**
VI	**Applications of Optimization Algorithms**	Case studies of optimization in engineering, economics, and operations research. Optimization in machine learning and artificial intelligence. Optimization in logistics, supply chain management, and energy systems. Optimization in network design and communication systems	**4**	**CO6**

Text Books:

1. "Introduction to Operations Research" by Frederick S. Hillier and Gerald J. Lieberman
2. "Optimization: Theory and Applications" by S. S. Rao
3. "Evolutionary Optimization Algorithms" by Dan Simon
4. "Practical Optimization: Algorithms and Engineering Applications" by Andreas Antoniou and Wu-Sheng Lu

References:

1. "Convex Optimization" by Stephen Boyd and Lieven Vandenberghe

2. "Metaheuristics: From Design to Implementation" by El-Ghazali Talbi
3. "Optimization Algorithms on Matrix Manifolds" by P.-A. Absil, R. Mahony, and R. Sepulchre
4. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy

Online References:

Website Name	
1.	MIT OpenCourseWare - Optimization Methods
2.	Coursera - Optimization Algorithms

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE2013	Computational Intelligence	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE2013	Computational Intelligence	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Computational Intelligence (CI) refers to the collection of biologically inspired computational techniques, including neural networks, evolutionary algorithms, fuzzy logic, and swarm intelligence, used to solve complex real-world problems. The course introduces the foundational principles and applications of CI methods to optimization, pattern recognition, classification, and decision-making tasks. By exploring different algorithms inspired by nature and human cognition, students will learn how to apply CI techniques to solve nonlinear, noisy, and uncertain problems in various domains.

Course Objectives:

1. To introduce the basic principles of computational intelligence and its components: neural networks, fuzzy systems, evolutionary algorithms, and swarm intelligence.
2. To develop an understanding of how CI methods can be used for optimization, decision-making, and problem-solving in real-world applications.
3. To explore the fundamental algorithms used in CI, such as Genetic Algorithms, Particle Swarm Optimization, Artificial Neural Networks, and Fuzzy Logic Systems.
4. To apply CI techniques to practical problems in areas such as image processing, control systems, robotics, and machine learning.
5. To analyze and compare the performance of CI algorithms with classical optimization methods.

6. To learn the integration of multiple CI techniques into hybrid systems to solve complex, multi-modal problems.

Course Outcomes:

1. Gain proficiency in key computational intelligence algorithms such as neural networks, fuzzy logic, genetic algorithms, and particle swarm optimization.
2. Apply CI techniques to solve optimization and machine learning problems, demonstrating their applicability in complex, dynamic environments.
3. Develop and implement hybrid CI systems that combine different computational intelligence paradigms to solve multi-objective problems.
4. Understand the limitations and strengths of various CI techniques and when to choose the right approach.
5. Solve real-world problems using CI algorithms in fields such as robotics, control, data analysis, and pattern recognition.
6. Critically evaluate the performance of CI-based solutions and optimize them for better accuracy and efficiency.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of AI.	**2**	--
I	**Introduction to Computational Intelligence**	Introduction to computational intelligence: Definition and scope. Overview of CI techniques: Neural networks, fuzzy logic, evolutionary algorithms, and swarm intelligence. Comparison of CI with traditional computational techniques. Real-world applications of computational intelligence in engineering, healthcare, finance, etc. Introduction to problem-solving using CI.	**6**	**CO1**
II	**Artificial Neural Networks (ANNs)**	Basic concepts: Neurons, activation functions, and network architectures. Perceptron model and its limitations. Multi-layer perceptrons (MLPs). Backpropagation algorithm for training neural networks. Advanced neural network models: Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs). Applications:	**7**	**CO2**

		Pattern recognition, classification, regression, and time series forecasting		
III	**Fuzzy Logic and Systems**	Introduction to fuzzy logic: Membership functions and fuzzy sets. Fuzzy rules, inference, and defuzzification techniques. Fuzzy logic controllers (FLCs) and applications in control systems. Mamdani and Sugeno models. Fuzzy clustering and pattern recognition. Applications in decision-making, control, and image processing.	**7**	**CO3**
IV	**Genetic Algorithms (GAs) and Evolutionary Computation**	Basics of evolutionary algorithms and genetic algorithms. Representation of solutions: Chromosomes and genetic operators (selection, crossover, mutation). Fitness function and selection techniques. GA convergence and performance metrics. Applications of GAs in optimization, machine learning, and scheduling problems. Hybrid algorithms combining GAs with other CI techniques.	**6**	**CO4**
V	**Particle Swarm Optimization (PSO) and Swarm Intelligence**	Introduction to swarm intelligence and basic PSO concepts. PSO algorithm: Particle position, velocity, and update rules. Modifications to PSO (e.g., adaptive, multi-objective PSO). Applications of PSO in continuous optimization, engineering design, and machine learning. Comparison of PSO with genetic algorithms and other evolutionary techniques. Hybrid PSO techniques and their applications	**7**	**CO5**
VI	**Hybrid Computational Intelligence Systems**	Introduction to hybrid CI systems and their advantages. Combining neural networks with fuzzy logic and evolutionary algorithms. Neuro-fuzzy systems and their applications. Evolutionary neural	**4**	**CO6**

		networks: Genetic Algorithms for training neural networks. Multi-objective optimization using hybrid CI approaches. Case studies of hybrid systems in robotics, control, and autonomous systems		

Text Books:

1. "Computational Intelligence: An Introduction" **by Andries P. Engelbrecht**
2. "Neural Networks and Fuzzy Systems" **by Bart Kosko**
3. "Genetic Algorithms in Search, Optimization, and Machine Learning" **by David E. Goldberg**
4. "Swarm Intelligence" **by Christian Blum and Mengjie Zhang**

References:

1. "Fuzzy Logic with Engineering Applications" **by Timothy J. Ross**
2. "Machine Learning: A Probabilistic Perspective" **by Kevin P. Murphy**
3. "Metaheuristics for Hard Optimization" **by Pascal Van Hentenryck and Laurent Michel**
4. "Practical Computational Intelligence" **by Witold Pedrycz and Andrzej Skowron**

Online References:

Website Name	
1.	Coursera - Computational Intelligence
2.	MIT OpenCourseWare
3.	Swarm Intelligence – SpringerLink
4.	Artificial Intelligence & Computational Intelligence – Stanford

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL2011	Swarm Intelligence Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL2011	Swarm Intelligence Lab	--	--	--	--	25	25	50

Lab Objectives: Students will be able:

1. To introduce students to the implementation of biologically inspired swarm algorithms.
2. To enable hands-on understanding of Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and related algorithms.
3. To solve real-world optimization problems using swarm intelligence techniques.
4. To develop swarm-based applications in robotics, networking, and machine learning.
5. To evaluate and compare performance of different swarm-based approaches.
6. To integrate hybrid swarm systems and explore advancements in algorithmic design.

Lab Outcomes:

Upon completion of this lab, students will be able to:

1. Implement and simulate core swarm intelligence algorithms like PSO, ACO, and ABC.
2. Solve single and multi-objective optimization problems using swarm-based approaches.
3. Design swarm-based control algorithms for applications in robotics and IoT.
4. Evaluate and benchmark swarm algorithms against standard datasets or scenarios.
5. Identify suitable swarm algorithms for given problem domains.
6. Explore hybrid and advanced swarm techniques for complex applications.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of Algorithms & Programming.	02	--
I	**Introduction to Swarm Intelligence & Basic Implementation**	Overview of swarm systems and self-organization. Tools: Python /MATLAB/R, matplotlib/seaborn for visualization.	**04**	**LO1**
II	**Particle Swarm Optimization (PSO)**	PSO fundamentals: velocity and position update rules. Constriction coefficient, inertia weight strategies.	**04**	**LO2**
III	**Ant Colony Optimization (ACO)**	Pheromone update, path construction, evaporation. Application to combinatorial problems.	**04**	**LO3**
IV	**Other Swarm Algorithms**	Artificial Bee Colony (ABC). Firefly Algorithm (FA), Bat Algorithm, Grey Wolf Optimizer.	**04**	**LO4**
V	**Applications & Hybrid Systems**	Multi-agent systems. Swarm robotics (simulated). Hybrid metaheuristics	**04**	**LO5**
VI	**Real-World Problem Solving and Project Work**	Feature selection in datasets. IoT or WSN optimization. Real-world case studies.	**04**	**LO6**

Text Books:

1. "Swarm Intelligence: From Natural to Artificial Systems" – Eric Bonabeau, Marco Dorigo, Guy Theraulaz
2. "Nature-Inspired Optimization Algorithms" – Xin-She Yang
3. "Artificial Intelligence: A Guide to Intelligent Systems" – Michael Negnevitsky

References:

1. "Particle Swarm Optimization" – Maurice Clerc
2. "Ant Colony Optimization" – Marco Dorigo, Thomas Stützle
3. "Swarm Intelligence for Multi-objective Problems in Data Mining" – Carlos A. Coello Coello
4. "Metaheuristics: From Design to Implementation" – El-Ghazali Talbi

Online Resources:

1. IEEE Xplore – Swarm Intelligence Research
2. MIT OpenCourseWare – AI and Computational Intelligence
3. Coursera – Swarm Intelligence Courses

4. Springer – Swarm Intelligence Publications
5. GitHub – Swarm Optimization Projects

List of Experiments.

Sr No	List of Experiments	Hrs
01	Basic simulation of a swarm (e.g., boids or bird flocking model)	02
02	Visualizing the behavior of multiple agents interacting	02
03	Implement PSO for benchmark mathematical functions (Sphere, Rastrigin, Rosenbrock)	02
04	PSO-based optimization of hyperparameters in a machine learning model	02
05	Implement ACO for the Traveling Salesman Problem (TSP)	02
06	ACO application to shortest path discovery in a network graph.	02
07	Solve benchmark optimization problems using ABC and Firefly Algorithm	02
08	Compare convergence rates of ABC vs PSO vs ACO	02
09	PSO + Genetic Algorithm hybrid for function optimization	02
10	Swarm-based robot path planning simulation (MATLAB/Python)	02
11.	Use PSO/ACO for feature selection in a classification task (ML model)	02
12.	Mini-project: Select and solve a real-world optimization problem using swarm intelligence	02

Sr No	List of Assignments / Tutorials	Hrs
01	Comparative study of at least 3 swarm intelligence algorithms with implementation.	02
02	Research paper review on advanced swarm-based systems.	02
03	Develop a custom swarm algorithm or propose enhancements to an existing one.	02

04	Write a simulation report analyzing convergence behavior of different algorithms.	02
05	Real-world optimization case study: Industrial, logistics, or energy domain.	02
06	Document a hybrid optimization method using swarm intelligence and evolutionary techniques.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL2012	Optimization Algorithms Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL2012	Optimization Algorithms Lab	--	--	--	--	25	25	50

Lab Objectives: Students will be able:

1. To introduce students to the practical implementation of classical and modern optimization algorithms.
2. To solve linear, non-linear, and combinatorial optimization problems using different techniques.
3. To provide hands-on experience with deterministic and heuristic optimization methods.
4. To analyze the performance and convergence behavior of optimization algorithms.
5. To apply optimization techniques to real-world engineering and industrial problems.
6. To foster the ability to select and customize algorithms for specific applications.

Lab Outcomes:

Upon completion of this lab, students will be able to:

1. Implement classical optimization algorithms such as Gradient Descent, Newton's Method, and Simplex Method.
2. Solve real-world problems using metaheuristic algorithms like Genetic Algorithm (GA), Simulated Annealing (SA), and Particle Swarm Optimization (PSO).
3. Analyze algorithm efficiency, convergence, and stability.
4. Develop hybrid and problem-specific optimization techniques.
5. Compare optimization strategies and select appropriate methods for different types of problems.

6. Apply optimization algorithms in fields like machine learning, operations research, and engineering design.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	The Basics of Algorithms and Programming.	02	--
I	**Introduction to Optimization**	Types: Continuous, discrete, combinatorial. Deterministic vs. stochastic optimization. Objective functions and constraints.	**04**	**LO1**
II	**Linear and Nonlinear Programming**	Linear Programming (LP) formulation. Simplex method and duality. Nonlinear programming basics.	**04**	**LO2**
III	**Evolutionary Algorithms**	Genetic Algorithms (GA). Crossover, mutation, and selection strategies.	**04**	**LO3**
IV	**Swarm and Bio-Inspired Optimization**	Particle Swarm Optimization (PSO) fundamentals. Applications of swarm algorithms.	**04**	**LO4**
V	**Simulated Annealing and Other Heuristics**	Simulated Annealing (SA). Tabu Search, Differential Evolution (basic overview).	**04**	**LO5**
VI	**Hybrid Optimization and Applications**	Hybrid algorithms (GA+PSO, SA+PSO). Real-world applications (engineering design, ML hyperparameter tuning).	**04**	**LO6**

Text Books:

1. "Optimization in Operations Research" – Ronald L. Rardin
2. "Engineering Optimization: Theory and Practice" – Singiresu S. Rao
3. "Introduction to Optimization" – Pablo Pedregal

References:

1. "Metaheuristics: From Design to Implementation" – El-Ghazali Talbi
2. "Practical Optimization: Algorithms and Engineering Applications" – Andreas Antoniou, Wu-Sheng Lu
3. "Global Optimization Algorithms – Theory and Application" – Thomas Weise

Online Resources:

1. Coursera – Optimization Methods
2. edX – Introduction to Optimization
3. Springer – Optimization Research Papers
4. MIT OpenCourseWare – Numerical Optimization
5. GitHub – Optimization Algorithms Projects

List of Experiments.

Sr No	List of Experiments	Hrs
01	Implement basic function optimization using Gradient Descent.	02
02	Solve optimization problem using Newton-Raphson method.	02
03	Solve LP problems using the Simplex Method (manual + coding).	02
04	Implement Nonlinear optimization using penalty and barrier methods.	02
05	Implement a simple Genetic Algorithm for binary-coded optimization.	02
06	Solve TSP using Genetic Algorithm.	02
07	Solve benchmark functions (Sphere, Rastrigin) using PSO.	02
08	Comparative study: PSO vs GA for optimization problems.	02
09	Implement Simulated Annealing for a real-world scheduling problem.	02
10	Tabu Search for vehicle routing problems (conceptual + partial code).	02
11.	Design a hybrid GA-PSO algorithm for function optimization.	02
12.	Hyperparameter tuning of a machine learning model using GA or PSO.	02

Sr No	List of Assignments / Tutorials	Hrs
01	Literature survey on classical vs metaheuristic optimization algorithms.	02
02	Case study analysis: Choose and solve an industrial optimization problem.	02

03	Develop a hybrid optimization technique and demonstrate its benefits.	02
04	Performance benchmarking of GA, SA, PSO on multiple problems.	02
05	Application study: Optimization in Machine Learning or Neural Networks.	02
06	Write a report on emerging trends like Quantum Optimization and Reinforcement Learning-based Optimization.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE2013	Computational Intelligence Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPE 2013	Computational Intelligence Lab	--	--	--	--	25	25	50

Lab Objectives: Students will be able:

1. To provide hands-on experience in implementing computational intelligence techniques.
2. To enable solving optimization and classification problems using soft computing approaches.
3. To develop and simulate neural networks for predictive analytics.
4. To apply fuzzy logic for decision-making under uncertainty.
5. To integrate evolutionary algorithms with neural networks and fuzzy systems.
6. To expose students to real-world applications of CI in various domains like robotics, finance, and healthcare.

Lab Outcomes:

Upon completion of this lab, students will be able to:

1. Design and implement evolutionary algorithms for optimization tasks.
2. Apply neural networks for classification, regression, and clustering.
3. Build fuzzy inference systems for approximate reasoning and decision-making.
4. Evaluate the performance of computational intelligence techniques.
5. Develop hybrid intelligent systems for complex problem-solving.
6. Solve real-world case studies using computational intelligence frameworks.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping

0	Prerequisite	Basic of IoT and Programming.	02	--
I	**Introduction to Computational Intelligence**	Overview of CI paradigms. Tools and programming environments (MATLAB/Python).	**04**	**LO1**
II	**Artificial Neural Networks (ANN)**	Perceptron, Multi-layer Perceptron (MLP), Backpropagation. Activation functions, Training and Testing.	**04**	**LO2**
III	**Fuzzy Logic Systems**	Fuzzy sets, Membership functions. Fuzzy rules and inference mechanisms.	**04**	**LO3**
IV	**Genetic Algorithms (GA)**	Selection, crossover, mutation operators. GA for optimization and problem-solving.	**04**	**LO4**
V	**Hybrid Systems**	Neuro-fuzzy systems. Evolutionary neural networks.	**04**	**LO5**
VI	**Real-world Applications and Project Work**	CI in control systems, pattern recognition, bioinformatics. Case study analysis	**04**	**LO6**

Text Books:

1. "Computational Intelligence: An Introduction" – Andries P. Engelbrecht
2. "Neural Networks, Fuzzy Systems and Evolutionary Algorithms" – S. Rajasekaran and G.A. Vijayalakshmi Pai
3. "Artificial Intelligence: A Guide to Intelligent Systems" – Michael Negnevitsky

References:

1. "Fuzzy Sets and Fuzzy Logic: Theory and Applications" – George J. Klir, Bo Yuan
2. "Evolutionary Computation: Toward a New Philosophy of Machine Intelligence" – David B. Fogel
3. "Pattern Recognition and Machine Learning" – Christopher M. Bishop
4. "Soft Computing and Intelligent Systems Design" – Fakhreddine O. Karray and Clarence De Silva

Online Resources:

1. IEEE Xplore – Computational Intelligence Research
2. Springer – Journal of Computational Intelligence
3. Coursera – Courses on Computational Intelligence
4. MIT OpenCourseWare – Artificial Intelligence Labs
5. GitHub – Repositories on Computational Intelligence

List of Experiments.

Sr No	List of Experiments	Hrs
01	Basic implementation of optimization problems using random search.	02
02	Visualization of solution spaces.	02
03	Implement single-layer perceptron for logic gates (AND, OR).	02
04	Develop MLP for handwritten digit classification (MNIST dataset using TensorFlow/Keras or PyTorch).	02
05	Design a fuzzy controller for temperature regulation.	02
06	Implementation of fuzzy decision-making for an autonomous robot.	02
07	Implement GA for maximizing a given mathematical function.	02
08	Use GA for solving the Traveling Salesman Problem (TSP).	02
09	Implement Adaptive Neuro-Fuzzy Inference System (ANFIS) for predictive modeling.	02
10	Evolve neural networks using Genetic Algorithms.	02
11.	Real-world case study: Predicting stock prices using ANN.	02
12.	Mini-project: Select a real-world problem and solve using a CI approach.	02

Sr No	List of Assignments / Tutorials	Hrs
01	Comparative analysis of different CI techniques on a standard dataset.	02
02	Report on a real-world application of computational intelligence.	02
03	Develop a hybrid system combining two CI paradigms (e.g., GA + ANN).	02
04	Literature review of recent research papers on Computational Intelligence.	02

05	Design a fuzzy inference system for a healthcare-related problem.	02
06	Simulation of swarm intelligence algorithms in a multi-agent system.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC301	Product Design & Development	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC301	Product Design & Development	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course provides a comprehensive understanding of product design and development processes**,** covering concept generation, prototyping, design for manufacturing (DFM), user-centered design, and product lifecycle management (PLM)**.** The course integrates engineering, business, and design principles to equip students with the skills needed to develop innovative, cost-effective, and market-driven products.

Course Objectives:

1. To introduce fundamental principles and methodologies of product design and development.
2. To explore user-centered design and customer needs analysis for effective product development.
3. To understand concept generation, evaluation, and prototyping techniques.
4. To analyze the impact of materials, manufacturing, and sustainability on product design.

5. To develop skills in computer-aided design (CAD) and simulation tools for design validation.
6. To examine product lifecycle management (PLM) and go-to-market strategies.

Course Outcomes:

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

1. Demonstrate an understanding of the product design process from ideation to commercialization.
2. Apply customer-centric design principles to develop innovative products.
3. Utilize CAD software and rapid prototyping for product development.
4. Implement design for manufacturing (DFM) and sustainability concepts.
5. Evaluate market feasibility, cost analysis, and product validation.
6. Develop a comprehensive product design proposal, considering technical, business, and social aspects.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of C programming.	**2**	--
I	**Introduction to Product Design & Development**	Overview of Product Design and Development. Product Life Cycle (PLC) and market requirements. Stages of product development: Concept, Design, Manufacturing, Testing, Launch. Interdisciplinary nature of product design (Engineering, Business, and Design)	**6**	**CO1**
II	**Customer Needs, Ideation & Concept Development**	Customer research and need identification. Brainstorming, mind mapping, and TRIZ methodology. Concept generation and selection (Morphological analysis, Decision matrices). Case studies of successful product innovations	**7**	**CO2**
III	**Product Architecture & Prototyping**	Modular vs. integral design approaches. Functional decomposition and system design Prototyping techniques: 3D Printing, CNC Machining, Virtual Prototyping. Concept validation and user testing	**7**	**CO3**

IV	**Design for Manufacturing (DFM) and Sustainability**	Material selection for product design. Design for Assembly (DFA), Manufacturing (DFM), and Environment (DFE). Sustainability and Green Design principles. Cost estimation and value engineering.	**6**	**CO4**
V	**Product Lifecycle Management & Market Launch**	Product Lifecycle Management (PLM) tools. Quality function deployment (QFD) and Failure Mode & Effects Analysis (FMEA). Intellectual Property (IP) and Patents in product development. Business strategies, marketing, and launch planning	**7**	**CO5**
VI	**Emerging Trends and Case Studies**	Industry 4.0 and digital product development. AI-driven design and smart products. Case studies of product failures and successes. Final project presentation: Developing a product from concept to prototype	**4**	**CO6**

Text Books:

1. Karl T. Ulrich & Steven D. Eppinger, *Product Design and Development*, McGraw-Hill.
2. Kevin Otto & Kristin Wood, *Product Design: Techniques in Reverse Engineering and New Product Development*, Pearson.
3. David G. Ullman, *The Mechanical Design Process*, McGraw-Hill.
4. Michael F. Ashby, *Materials Selection in Mechanical Design*, Elsevier.

References:

1. Stuart Pugh, *Total Design: Integrated Methods for Successful Product Engineering*, Addison-Wesley.
2. Erik K. Antonsson & Jonathan Cagan, *Formal Engineering Design Synthesis*, Cambridge University Press.
3. Bo Bergman & Bengt Klefsjö, *Quality: From Customer Needs to Customer Satisfaction*, Studentlitteratur AB.
4. Don Norman, *The Design of Everyday Things*, Basic Books.

Online References:

Website Name
1. MIT OpenCourseWare – Product Design & Development – https://ocw.mit.edu 2. IDEO Design Thinking and Innovation Resources – https://www.ideo.com 3. Coursera – Product Design and Manufacturing Courses – https://www.coursera.org 4. Harvard Business Review – Product Innovation & Design Articles – https://hbr.org 5. National Institute of Design (NID) – Design and Innovation Case Studies – https://www.nid.edu

6. Autodesk & SolidWorks Tutorials for Product Design – https://www.autodesk.com

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC302	Machine Learning	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC302	Machine Learning	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Machine Learning (ML) is a subfield of artificial intelligence that focuses on developing algorithms capable of learning from data and making decisions without being explicitly programmed. This course introduces students to the fundamental concepts, techniques, and applications of machine learning, focusing on supervised, unsupervised, and reinforcement learning methods. By the end of the course, students will understand the theoretical foundations of machine learning algorithms and gain hands-on experience in implementing them using popular machine learning tools.

Course Objectives:

1. To introduce students to the basic concepts and terminology of machine learning, including types of learning, algorithms, and evaluation metrics.
2. To explore various supervised learning algorithms, such as linear regression, decision trees, and support vector machines, and their applications.
3. To understand unsupervised learning techniques such as clustering, dimensionality reduction, and anomaly detection.
4. To introduce reinforcement learning and its applications in decision-making and control problems.
5. To teach students how to evaluate machine learning models using appropriate metrics and cross-validation techniques.

6. To enable students to implement machine learning algorithms using Python and popular ML libraries like scikit-learn, TensorFlow, and Keras.

Course Outcomes:

1. Understand the basic principles and types of machine learning, including supervised, unsupervised, and reinforcement learning.
2. Develop and implement machine learning algorithms to solve practical problems in areas such as classification, regression, clustering, and optimization.
3. Evaluate and compare different machine learning models using appropriate metrics and techniques such as cross-validation.
4. Use Python libraries such as scikit-learn and TensorFlow to implement and experiment with machine learning models.
5. Apply dimensionality reduction and feature engineering techniques to improve model performance.
6. Solve real-world problems in machine learning by integrating algorithms, data processing techniques, and evaluation methods.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of AI and Python.	**2**	--
I	**Introduction to Machine Learning**	What is Machine Learning? Types of Machine Learning (Supervised, Unsupervised, Reinforcement Learning). Overview of key machine learning algorithms and their applications. The machine learning pipeline: Data collection, data preprocessing, model training, evaluation, and deployment. Introduction to Python for Machine Learning: Libraries (NumPy, Pandas, scikit-learn). Overview of supervised vs. unsupervised learning.	**6**	**CO1**
II	**Supervised Learning Algorithms**	Linear Regression: Concept, cost function, gradient descent, and implementation. Logistic Regression: Binary classification, sigmoid function, cross-entropy loss. Decision Trees: Splitting criteria (Gini index, entropy), overfitting, pruning. Support Vector Machines (SVM): Linear and non-linear SVM, kernel trick, hyperplane. K-Nearest Neighbors (KNN): Distance metrics, classification, and regression with KNN	**7**	**CO2**
III	**Unsupervised Learning Algorithms**	Clustering Algorithms: K-means clustering, hierarchical clustering,	**7**	**CO3**

		DBSCAN. Dimensionality Reduction: Principal Component Analysis (PCA), t-SNE, and feature selection techniques. Anomaly Detection: One-class SVM, Isolation Forest. Gaussian Mixture Models (GMMs): Understanding mixture models and EM algorithm. Association Rule Learning: Apriori algorithm, market basket analysis		
IV	**Model Evaluation and Hyperparameter Tuning**	Model Evaluation Metrics: Accuracy, precision, recall, F1-score, ROC curve, AUC. Overfitting and Underfitting: Bias-variance trade-off, regularization techniques (L1, L2). Cross-Validation: k-fold cross-validation, stratified sampling. Hyperparameter Tuning: Grid search, random search, and Bayesian optimization. Ensemble Methods: Bagging, Boosting, Random Forest, AdaBoost, Gradient Boosting	**6**	**CO4**
V	**Deep Learning and Neural Networks**	Introduction to Neural Networks: Perceptrons, activation functions, forward and backward propagation. Feedforward Neural Networks (FNNs): Architecture, backpropagation, and gradient descent. Convolutional Neural Networks (CNNs): Convolution and pooling layers, image classification. Recurrent Neural Networks (RNNs): Time series prediction, Long Short-Term Memory (LSTM). Transfer Learning: Fine-tuning pre-trained models, applications in image and text processing	**7**	**CO5**
VI	**Reinforcement Learning and Applications**	Introduction to Reinforcement Learning: Rewards, states, actions, and policies. Q-learning: Exploration vs. exploitation, Bellman equation Deep Q Networks (DQNs): Combining neural networks with Q-learning. Policy Gradient Methods: REINFORCE algorithm. Applications: Game playing (e.g., AlphaGo), robotics, autonomous systems	**4**	**CO6**

Text Books:

1. "Pattern Recognition and Machine Learning" by Christopher Bishop
2. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy
3. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron

4. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville

References:

1. "Introduction to Machine Learning with Python" by Andreas C. Müller and Sarah Guido
2. "Deep Learning with Python" by François Chollet
3. "Machine Learning Yearning" by Andrew Ng
4. "The Elements of Statistical Learning" by Trevor Hastie, Robert Tibshirani, and Jerome Friedman

Online References:

Website Name	
1.	Coursera - Machine Learning
2.	Scikit-learn Documentation
3.	DeepLearning.AI
4.	TensorFlow Documentation

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC303	Embedded System Design	**3**	**-**	**-**	**3**	**-**	**-**	**3**

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC303	Embedded System Design	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Embedded System Design is a multidisciplinary field that integrates hardware and software to develop real-time computing systems. This course covers fundamental concepts of embedded systems, microcontrollers, real-time operating systems (RTOS), hardware-software co-design, and applications in industries like automotive, consumer electronics, healthcare, and aerospace. The course emphasizes practical implementations, industry standards, and emerging trends in embedded technologies.

Course Objectives:

1. To understand the fundamental concepts and components of embedded systems.
2. To introduce microcontrollers and their role in embedded applications.
3. To explore real-time operating systems (RTOS) and their implementation in embedded systems.
4. To develop skills in hardware-software co-design and system optimization.
5. To analyze communication protocols and interfacing techniques used in embedded systems.
6. To examine real-world applications and emerging trends in embedded system design.

Course Outcomes:

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

1. Design and develop embedded systems for real-time applications.
2. Implement microcontroller-based applications with appropriate hardware and software integration.
3. Apply RTOS concepts for efficient task scheduling and system management.
4. Develop and optimize embedded hardware and software for energy-efficient performance.
5. Interface sensors, actuators, and communication modules in embedded applications.
6. Explore emerging technologies such as IoT, AI-driven embedded systems, and industry automation.

DETAILED SYinLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of Operating system.	**2**	--
I	**Introduction to Embedded Systems**	Definition and characteristics of embedded systems. Embedded vs. general-purpose computing. Design metrics and constraints. Embedded system development life cycle. Applications in various industries	**6**	**CO1**
II	**Microcontrollers and Embedded Processors**	Overview of microcontrollers and embedded processors. Architecture of popular microcontrollers (e.g., ARM Cortex, AVR, PIC). Memory hierarchy and management. Peripheral interfacing (GPIO, Timers, ADC, DAC). Power management in embedded systems	**7**	**CO2**
III	**Real-Time Operating Systems (RTOS) and Scheduling**	Introduction to RTOS concepts Multitasking, scheduling algorithms, and task management Inter-process communication (IPC) and synchronization. Memory management in RTOS. Case study: RTOS in industrial applications	**7**	**CO3**
IV	**Hardware-Software Co-Design & Optimization**	Embedded system design methodologies. Hardware acceleration and co-processing. Firmware development and debugging. Low-power design techniques. Case study: Power-efficient embedded systems	**6**	**CO4**
V	**Embedded Communication Protocols & Interfacing**	Serial communication protocols (UART, SPI, I2C). Wireless communication (Bluetooth, Zigbee, LoRa, Wi-Fi). CAN Bus, LIN, and industrial communication protocols. Sensor and actuator interfacing Case study: Smart sensor networks in embedded systems	**7**	**CO5**
VI	**Applications and**	Embedded systems in IoT applications. AI and	**4**	**CO6**

	Emerging Trends	machine learning in embedded systems. Security challenges in embedded system design. Edge computing and cloud integration. Case studies: Embedded systems in automotive, healthcare, and industrial automation		

Text Books:

1. "Embedded Systems: A Contemporary Design Tool" – James K. Peckol
2. "Embedded Systems Design: An Introduction to Processes, Tools, and Techniques" – Arnold S. Berger
3. "Real-Time Systems and Programming Languages" – Alan Burns, Andy Wellings
4. "ARM System Developer's Guide: Designing and Optimizing System Software" – Andrew Sloss, Dominic Symes, Chris Wright

References:

1. "Embedded Systems: Architecture, Programming, and Design" – Raj Kamal
2. "Designing Embedded Hardware" – John Catsoulis
3. "Real-Time Concepts for Embedded Systems" – Qing Li
4. "Introduction to Embedded Systems: A Cyber-Physical Systems Approach" – Edward A. Lee, Sanjit A. Seshia

Online References:

Website Name
1. ARM Developer – ARM-based embedded system resources.
2. Embedded.com – Industry insights and design resources.
3. IEEE Xplore – Research papers and case studies.
4. Texas Instruments Embedded Systems – MCU documentation and application notes.
5. Open-Source RTOS – FreeRTOS for embedded applications.

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPARP301	Research Project	Entire Semester			4	-	-	4

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPARP301	Research Project	--	--	--	--	--	100	100	200

Research Project Guidelines for M.Tech Courses

1. Introduction The M.Tech research project is a crucial component of the curriculum, designed to encourage innovation, critical thinking, and problem-solving skills. This document provides guidelines for planning, executing, and evaluating research projects.

2. Objectives

- To develop research-oriented thinking and technical expertise.
- To apply theoretical knowledge to solve real-world engineering problems.
- To enhance skills in research methodology, experimentation, and technical writing.

3. Eligibility

- Students must have completed at least one semester of the M.Tech program.
- Research topics should be aligned with the student's area of specialization.

4. Project Selection

- Students should choose a research topic in consultation with their faculty advisor.
- The topic must be innovative, feasible, and contribute to the advancement of knowledge.
- A formal project proposal must be submitted and approved by the department.

5. Research Methodology

- Define clear research objectives and hypotheses.
- Conduct a thorough literature review to understand the current state of research.
- Choose appropriate research methods (experimental, computational, analytical, etc.).
- Maintain a structured timeline with milestones for progress tracking.

6. Supervision & Mentorship

- Each student will be assigned a faculty guide by HoD for guidance and evaluation.
- Regular meetings with the guide should be scheduled to discuss progress.
- Industry collaboration is encouraged for applied research projects.

7. Documentation & Reporting

- Maintain a research journal/logbook documenting progress and challenges.
- Prepare periodic progress reports as per university guidelines.
- Submit a mid-term review report for evaluation.
- The final research report should include:
  - Abstract
  - Introduction & Literature Review
  - Methodology
  - Experimental Results/Findings
  - Conclusion & Future Scope
  - References

8. Evaluation Criteria

- Research quality and originality (30%)
- Methodology and technical rigor (30%)
- Documentation and report quality (20%)
- Presentation and viva-voce (20%)

9. Code of Conduct & Ethics

- Maintain academic integrity and avoid plagiarism.
- Follow ethical research practices, including data confidentiality.
- Any misconduct may result in academic penalties.

10. Important Deadlines

- Submission of research project proposal for sem III and sem IV: One Week before the Semester Start to the college department.
- Mid-term evaluation: Two review need to be conducted by the department: 1st review in 2nd week after semester start and then 2nd review between 8th to 10th week of the semester.
- Final report submission: as per term work submission date of UoM.
- Viva-voce & presentation: as per UoM policies.

For above details, students should consult their department's coordinator.

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 100 Marks (Total marks) = 70 Marks (Research) + 25 Marks (Report) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above Research Project.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL 301	Product Design & Development Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL301	Product Design & Development Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide hands-on experience in product conceptualization, design, and prototyping.
2. To develop skills in customer need analysis and ideation techniques for product innovation.
3. To apply CAD tools, prototyping methods, and design evaluation techniques.
4. To implement Design for Manufacturing (DFM), Design for Assembly (DFA), and Design for Sustainability (DFS) principles.
5. To analyze the cost, feasibility, and market potential of product designs.
6. To develop and present a complete product prototype with design documentation.

Lab Outcomes:

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

1. Translate customer needs into design requirements.
2. Generate and evaluate multiple product concepts using systematic design methods.
3. Utilize CAD software and 3D printing for product modeling and prototyping.
4. Apply DFM, DFA, and sustainability principles in product design.
5. Conduct cost analysis, material selection, and feasibility studies.
6. Develop and present a functional product prototype with detailed documentation.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of C Programming	02	
I	**Introduction to Product Design & Concept Development**	Understanding user needs and market analysis. Idea generation techniques: Brainstorming, TRIZ, Morphological Analysis. Case studies of innovative product designs.	**04**	**LO1**
II	**CAD Modeling and Virtual Prototyping**	Introduction to SolidWorks, CATIA, AutoCAD, Fusion 360. 3D modeling of mechanical and industrial products. Rendering and animation for design visualization	**04**	**LO2**
III	**Rapid Prototyping and 3D Printing**	Basics of additive manufacturing (FDM, SLA, SLS). Hands-on 3D printing of designed models. Tolerances and surface finishing in prototypes	**04**	**LO3**
IV	**Design for Manufacturing (DFM) & Sustainability**	Material selection for strength, durability, and cost-effectiveness. Design considerations for plastic injection molding, CNC machining, and sheet metal. Eco-design and lifecycle assessment of products	**04**	**LO4**
V	**Cost Analysis, Market Feasibility & Product Testing**	Cost estimation methods for product manufacturing. Failure Mode and Effects Analysis (FMEA) and Quality Function Deployment (QFD). Performance testing and validation of product prototypes	**04**	**LO5**
VI	**Final Project – Complete Product Development**	Develop a real-world product prototype. Document design iterations, material selection, and feasibility analysis. Final presentation and product demonstration.	**04**	**LO6**

Text Books:

1. Karl T. Ulrich & Steven D. Eppinger, *Product Design and Development*, McGraw-Hill.
2. Kevin Otto & Kristin Wood, *Product Design: Techniques in Reverse Engineering and New Product Development*, Pearson.
3. David G. Ullman, *The Mechanical Design Process*, McGraw-Hill.
4. Michael F. Ashby, *Materials Selection in Mechanical Design*, Elsevier.

References:

1. Stuart Pugh, *Total Design: Integrated Methods for Successful Product Engineering*, Addison-Wesley.
2. Erik K. Antonsson & Jonathan Cagan, *Formal Engineering Design Synthesis*, Cambridge University Press.
3. Bo Bergman & Bengt Klefsjö, *Quality: From Customer Needs to Customer Satisfaction*, Studentlitteratur AB.
4. Don Norman, *The Design of Everyday Things*, Basic Books.

Online Resources:

Website Name
1. MIT OpenCourseWare – Product Design & Development – https://ocw.mit.edu 2. IDEO Design Thinking and Innovation Resources – https://www.ideo.com 3. Coursera – Product Design and Manufacturing Courses – https://www.coursera.org 4. Harvard Business Review – Product Innovation & Design Articles – https://hbr.org 5. National Institute of Design (NID) – Design and Innovation Case Studies – https://www.nid.edu 6. Autodesk & SolidWorks Tutorials for Product Design – https://www.autodesk.com

List of Experiments.

Sr No	List of Experiments	Hrs
01	Customer Needs Analysis: Conduct surveys and identify product requirements.	02
02	Concept Generation & Selection: Apply TRIZ, brainstorming, and decision matrices.	02
03	CAD Modeling & Virtual Prototype: Create a 3D model of a selected product concept.	02
04	3D Printing & Prototyping: Fabricate a physical prototype using FDM/SLA 3D printing.	02

05	Material Selection & Cost Analysis: Evaluate materials and production costs.	02
06	Design for Manufacturing & Assembly: Optimize a design for large-scale production.	02
07	Product Lifecycle & Sustainability Analysis: Assess environmental impact using LCA tools.	02
08	Market Feasibility Study: Analyze customer feedback and competitive products.	02
09	Failure Analysis & Design Improvements: Identify weaknesses and refine designs.	02
10	Final Product Development & Presentation: Develop, test, and showcase a product prototype.	02

Sr No	List of Assignments / Tutorials	Hrs
01	Case Study on an Innovative Product: Research and present an analysis of a groundbreaking product.	02
02	Comparative Study on Manufacturing Methods: Compare different production techniques and material choices.	02
03	3D Modeling Report: Design a real-world product and document the process.	02
04	Sustainability & Lifecycle Analysis: Conduct an LCA for an assigned product.	02
05	Business & Costing Assignment: Estimate manufacturing costs and prepare a business model.	02
06	Final Product Development Report: Submit a detailed report on a self-developed product prototype.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL 302	Machine Learning Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL302	Machine Learning Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide practical experience in implementing basic machine learning algorithms.
2. To enable students to preprocess, analyze, and visualize datasets.
3. To train students to build, validate, and optimize predictive models.
4. To introduce the practical challenges of overfitting, model selection, and performance evaluation.
5. To familiarize students with real-world machine learning applications in different domains.
6. To build capabilities for using modern ML frameworks such as Scikit-learn, TensorFlow, and PyTorch.

Lab Outcomes:

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

1. Understand and apply various supervised and unsupervised machine learning techniques.
2. Perform data preprocessing, feature engineering, and exploratory data analysis.
3. Implement machine learning models using Python libraries like Scikit-learn, TensorFlow, or Keras.
4. Evaluate models using appropriate performance metrics and validation techniques.
5. Handle real-world datasets and derive meaningful insights.
6. Build and deploy machine learning pipelines for end-to-end problem solving.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of AI.	02	
I	**Data Preprocessing and Basic ML Concepts**	Introduction to machine learning tools: Python, Scikit-learn, Pandas, Matplotlib. Data preprocessing: missing values, encoding categorical variables, feature scaling. Train-test split, cross-validation.	**04**	**LO1**
II	**Supervised Learning - Regression**	Linear regression, Ridge and Lasso regression.Polynomial regression.	**04**	**LO2**
III	**Supervised Learning – Classification**	Logistic regression, Decision Trees, Random Forest, SVM, KNN. Model evaluation metrics (Accuracy, Precision, Recall, F1 Score, ROC-AUC).	**04**	**LO3**
IV	**Unsupervised Learning**	Clustering: K-Means, Hierarchical clustering. Dimensionality Reduction: PCA, t-SNE.	**04**	**LO4**
V	**Advanced Topics**	Ensemble Methods: Bagging, Boosting (AdaBoost, XGBoost). Introduction to Neural Networks using Keras/TensorFlow.	**04**	**LO5**
VI	**Real-world Project Work**	Model deployment basics: saving models, loading, and using them. Deployment on platforms like Flask/Streamlit (basic introduction).	**04**	**LO6**

Text Books:

1. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" – Aurélien Géron
2. "Pattern Recognition and Machine Learning" – Christopher M. Bishop
3. "Machine Learning" – Tom M. Mitchell

References:

1. "Python Machine Learning" – Sebastian Raschka and Vahid Mirjalili
2. "Machine Learning: A Probabilistic Perspective" – Kevin P. Murphy
3. "Deep Learning" – Ian Goodfellow, Yoshua Bengio, and Aaron Courville

Online Resources:

Website Name
1. Scikit-learn Documentation 2. Kaggle Datasets & Competitions 3. TensorFlow Tutorials 4. Coursera – Machine Learning by Andrew Ng 5. MIT OpenCourseWare – Machine Learning Courses

List of Experiments.

Sr No	List of Experiments	Hrs
01	Data cleaning and preprocessing on UCI datasets	02
02	Exploratory Data Analysis (EDA) with Pandas and Seaborn	02
03	Implement simple and multiple linear regression models	02
04	Predict housing prices using Boston Housing Dataset	02
05	Ridge and Lasso regression comparative study	02
06	Implement logistic regression on binary classification dataset.	02
07	Build a Decision Tree and Random Forest classifier on Titanic dataset	02
08	SVM and KNN comparison on Iris dataset	02
09	Implement K-Means clustering on customer segmentation dataset	02
10	Apply PCA for dimensionality reduction on digit recognition dataset	02
11	Hierarchical clustering visualization	02
12	Implement AdaBoost and XGBoost classifiers	02
13	Build a simple ANN (Artificial Neural Network) for MNIST handwritten digits	02
14	Mini-project: End-to-end ML project on real-world data	02

Sr No	List of Assignments / Tutorials	Hrs
01	Research and report on real-world machine learning applications in automobile industry.	02
02	Implement regularization techniques and observe their effects on model performance.	02
03	Compare ensemble techniques (Bagging vs Boosting) on a noisy dataset.	02
04	Develop a complete machine learning pipeline from data preprocessing to model deployment.	02
05	Perform hyperparameter tuning using GridSearchCV and RandomizedSearchCV.	02
06	Document a critical comparison between classical ML algorithms and a simple neural network on a standard dataset	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL303	Embedded System Design Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL303	Embedded System Design Lab	--	--	--	--	25	25	50

Lab Objectives:

1. Understand the architecture and programming of microcontrollers and microprocessors.
2. Develop skills in interfacing sensors and actuators with embedded systems.
3. Design embedded systems for real-time applications using RTOS and IDEs.
4. Implement embedded C code for hardware and peripheral communication.
5. Explore communication protocols such as I2C, SPI, UART in embedded systems.
6. Develop mini-projects integrating hardware, software, and control systems.

Lab Outcomes:

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

1. Demonstrate hands-on experience in programming microcontrollers like ARM, AVR, or Arduino.
2. Interface embedded devices with sensors, actuators, and displays.
3. Implement embedded communication protocols (UART, SPI, I2C).
4. Design embedded systems for real-time and control-based applications.
5. Evaluate embedded system performance using debugging and analysis tools.
6. Work collaboratively to build, simulate, and test embedded applications.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of Microprocessor and Microcontroller.	02	
I	**Introduction to Embedded Systems & Development Tools**	⌜ Embedded system architecture ⌜ IDEs: Keil, Arduino, MPLAB, STM32CubeIDE ⌜ Introduction to Embedded C	**04**	**LO1**
II	**Microcontroller Programming**	⌜ Register-level programming ⌜ Delay routines and timers ⌜ ADC and DAC basics	**04**	**LO2**
III	**Sensor and Actuator Interfacing**	⌜ Interfacing IR, temperature, ultrasonic sensors ⌜ Driving actuators: motors, relays	**04**	**LO3**
IV	**Communication Protocols**	⌜ UART, SPI, I2C protocols ⌜ Serial communication between MCU and PC	**04**	**LO4**
V	**Embedded System Integration**	⌜ Real-time data acquisition and display ⌜ Interrupt programming ⌜ Real-time clock and alarms	**04**	**LO5**
VI	**Real-Time Systems**	⌜ RTOS basics (FreeRTOS intro) ⌜ Task scheduling and	**04**	**LO6**

		multitasking		

Text Books:

1. "Embedded Systems: Architecture, Programming and Design" – Raj Kamal
2. "Embedded System Design" – Frank Vahid and Tony Givargis
3. "The 8051 Microcontroller and Embedded Systems" – Muhammad Ali Mazidi

References:

1. "ARM System Developer's Guide" – Andrew N. Sloss
2. "Programming Embedded Systems in C and C++" – Michael Barr
3. "Making Embedded Systems" – Elecia White
4. "Embedded C Programming and the Atmel AVR" – Barnett, Cox, O'Cull

Online Resources:

Website Name
1. https://www.coursera.org/learn/embedded-systems – Embedded Systems by University of Colorado 2. https://www.tutorialspoint.com/embedded_systems/index.htm – TutorialsPoint 3. https://www.electronicwings.com – Practical guides for sensors and boards 4. https://www.embedded.com – Industry-level tutorials 5. https://www.arduino.cc/en/Tutorial/HomePage – Arduino documentation and projects 6. https://www.st.com – STM32 datasheets, IDEs, and documentation

List of Experiments.

Sr No	List of Experiments	Hrs
01	Blinking LED using microcontroller (8051/AVR/ARM/Arduino)	02

02	Basic I/O operations (switches and LEDs)	02
03	Generating delay using timers	02
04	Analog signal reading using ADC module	02
05	Digital output using DAC	02
06	Interfacing a temperature sensor (e.g., LM35)	02
07	Obstacle detection using IR/Ultrasonic sensor	02
08	DC motor and relay control	02
09	UART-based communication with serial terminal	02
10	SPI protocol: Interfacing RTC or EEPROM	02
11	I2C-based communication with LCD/RTC	02
12	Real-time clock (RTC) based timer display on LCD	02
13	External interrupt handling (e.g., button press or sensor trigger)	02
14	PWM generation and duty cycle control	02
15	Task scheduling using basic RTOS (FreeRTOS or CMSIS-RTOS)	02

Sr No	List of Assignments / Tutorials	Hrs
01	Write embedded C code for GPIO toggling using delay.	02
02	Report on interfacing different types of sensors (analog vs digital).	02
03	Assignment on comparing UART, SPI, I2C communication protocols.	02
04	RTOS-based application simulation assignment.	02
05	Case study on embedded system used in automotive or medical domain.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE3011	CNC Machines	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE3011	CNC Machines	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Computer Numerical Control (CNC) machines are widely used in manufacturing for automating machining processes like drilling, milling, turning, and grinding. This course covers the

principles and practices of CNC machines, including their operation, programming, maintenance, and advanced control techniques. Students will gain hands-on experience with CNC equipment and software, while learning about the integration of CNC systems in the manufacturing process. The course emphasizes both the theoretical foundations and practical skills necessary for effective CNC machining.

Course Objectives:

1. To introduce students to the fundamentals of CNC machines, including their components, operation, and applications in manufacturing.
2. To understand the different types of CNC machines, such as vertical and horizontal milling machines, CNC lathes, and CNC routers.
3. To teach students how to program CNC machines using G-code and other programming languages.
4. To explore the role of CNC machines in automation and modern manufacturing systems.
5. To understand the maintenance, calibration, and troubleshooting of CNC machines.
6. To introduce advanced CNC techniques, such as multi-axis machining, 3D printing, and CNC in additive manufacturing.

Course Outcomes:

By the end of this course, students will:

1. Understand the basic principles and components of CNC machines and their applications in industry.
2. Be able to identify and differentiate between various CNC machine types and their uses.
3. Write and interpret G-code for CNC programming, including simple and complex toolpaths.
4. Program and operate CNC machines to perform machining operations such as milling, turning, and drilling.
5. Apply safety protocols and maintenance procedures for CNC machine operation.
6. Understand advanced CNC technologies, such as multi-axis machining and their role in modern manufacturing.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of mathematics.	**2**	--
I	**Introduction to CNC Machines**	Overview of CNC machines and their importance in modern manufacturing. Components of	**6**	**CO1**

		CNC systems: CNC controller, drives, motors, and feedback systems. Types of CNC machines: Milling machines, lathes, grinders, and routers. CNC machine tools and their functions. Coordinate system and axes (X, Y, Z axes, rotary axes). Basic machining operations: Turning, milling, drilling.		
II	**CNC Programming Basics**	Introduction to CNC programming and the role of G-code. Syntax and structure of G-code and M-code. Basic CNC programming commands: G0, G1, G2, G3, M codes, tool changes, etc. Introduction to CNC program structure: Start block, toolpath, end block. Simple CNC programs for turning and milling. Input and output of CNC programs	**7**	**CO2**
III	**CNC Machine Operation**	Setting up the CNC machine: Loading tools, fixtures, and workpieces. Machine startup and calibration. Loading and running CNC programs. Operating controls and monitoring machine performance. Tools and feeds: Tool selection, cutting speeds, and feed rates. CNC safety practices and precautions	**7**	**CO3**
IV	**Advanced CNC Programming**	Complex G-code commands for multi-axis machining. Toolpath generation for milling and turning operations. Coordinate transformations and offset handling Sub-programming and macros in CNC programming. Advanced techniques for contouring, profiling, and pocketing. CNC programming for 3D printing and additive manufacturing	**6**	**CO4**
V	**CNC Maintenance and Troubleshooting**	Routine maintenance tasks: Lubrication, cleaning, and inspection. Common CNC machine faults and their causes.	**7**	**CO5**

		Troubleshooting techniques: Diagnosing mechanical, electrical, and software problems. Calibration and alignment procedures for CNC machines. Replacement of CNC machine components (spindles, motors, etc.)		
VI	**CNC in Automation and Industry 4.0**	Integration of CNC machines in manufacturing automation. Industry 4.0: CNC in smart factories, IoT-enabled CNC machines. Robotics and CNC integration for automated machining. Advanced manufacturing techniques: 3D printing and additive manufacturing with CNC machines. CNC simulation software for virtual machining and optimization. Case studies of CNC machine applications in various industries	**4**	**CO6**

Text Books:

1. "CNC Control Setup for Milling and Turning" by Peter Smid
2. "CNC Programming Handbook" by Peter Smid
3. "Manufacturing Engineering and Technology" by Serope Kalpakjian and Steven Schmid
4. "Introduction to Computer Numerical Control" by Robert H. L.

References:

1. "CNC Machining Handbook" by James Madison
2. "Modern CNC Programming Techniques" by Bill R. White
3. "Principles of Modern Manufacturing" by Mikell P. Groover
4. "Computer Numerical Control" by Gary F. Dunning

Online References:

Website Name
1. CNC Cookbook 2. Haas Automation 3. MachiningCloud 4. CNC Simulator Pro 5. FANUC America

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL3011	CNC Machine Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL3011	CNC Machine Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide hands-on experience in CNC programming and machine operations.
2. To impart knowledge of G-code and M-code for various CNC operations.
3. To develop skills in simulation and tool path generation using CAD/CAM software.
4. To understand machine setup, tool selection, and process planning for CNC operations.
5. To analyze machining parameters and their effect on productivity and accuracy.
6. To introduce advanced CNC concepts such as multi-axis machining and automation.

Lab Outcomes:

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

1. Understand and write CNC part programs for turning and milling operations.
2. Operate CNC lathe and milling machines for component fabrication.
3. Simulate CNC tool paths using CAD/CAM software.
4. Optimize machining parameters to improve product quality and cycle time.
5. Select appropriate tooling, work holding, and fixtures for CNC operations.
6. Explore applications of CNC in advanced manufacturing and automation.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of CNC Machine.	02	
I	**Introduction to CNC Technology**	• CNC vs conventional machines • CNC machine components • Basics of machine coordinate systems (G54, G90, etc.)	**04**	**LO1**
II	**CNC Programming Basics**	• G-code and M-code fundamentals • Absolute vs Incremental programming • Tool length compensation, cutter radius compensation	**04**	**LO2**

III	**CNC Lathe Programming**	• Turning cycle commands (G71, G72) • Drilling, facing, threading programs • Tool path simulation for lathe	**04**	**LO3**
IV	**CNC Milling Programming**	• Face milling, contour milling, pocket milling • Circular interpolation (G02, G03) • Peck drilling and slotting	**04**	**LO4**
V	**Tool Path Simulation & Verification**	• Use of CAD/CAM software (e.g., Mastercam, Fusion 360) • Tool path generation and verification • NC code post-processing	**04**	**LO5**
VI	**Advanced CNC Concepts**	• Introduction to 4-axis and 5-axis CNC • Automation and integration with robotics • Industry 4.0 and CNC machine monitoring	**04**	**LO6**

Text Books:

1. "CNC Machines" – R.K. Rajput
2. "Computer Numerical Control Machines and Computer Aided Manufacture" – J. Talavage, J. Bernardo
3. "CAD/CAM: Computer-Aided Design and Manufacturing" – M.P. Groover and E.W. Zimmers

References:

1. “CNC Programming Handbook” – Peter Smid
2. “Automation, Production Systems, and Computer-Integrated Manufacturing” – Mikell P. Groover
3. “Manufacturing Automation” – Yusuf Altintas
4. “Numerical Control and Computer Aided Manufacturing” – P. Radhakrishnan

Online Resources:

Website Name
1. MIT OpenCourseWare – Manufacturing Processes 2. G-code Reference by LinuxCNC 3. Autodesk Fusion 360 Learning 4. Mastercam University 5. Coursera – CAD/CAM for Manufacturing 6. Haas CNC Learning Resources

List of Experiments.

Sr No	List of Experiments	Hrs
01	Introduction to CNC machine control panel and safety procedures	02
02	Programming and simulation of facing operation on CNC lathe	02
03	Programming and machining of step turning and grooving on CNC lathe	02
04	Programming and machining of thread cutting on CNC lathe	02
05	Face milling operation on CNC milling machine	02
06	Contour milling and drilling operation on CNC milling machine	02
07	Tool path simulation and verification in CAD/CAM software	02
08	Programming using canned cycles (G81, G83)	02

09	Post-processing and machine code generation	02
10	Introduction to 4-axis or simulation-based multi-axis machining	02

Sr No	List of Assignments / Tutorials	Hrs
01	Write manual G-code for a turning part with multiple features	02
02	Simulate a 2D contour milling operation in CAM software	02
03	Analyze effect of speed, feed, and depth of cut on surface finish	02
04	Case study: Comparison of tool wear in conventional vs CNC machining	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE3012	Advanced Process Control	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE3012	Advanced Process Control	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

Advanced Process Control (APC) is an essential field in industrial automation that enhances process efficiency, reduces energy consumption, and improves product quality. This course provides an in-depth study of control strategies, model-based control techniques, optimization methods, and real-time industrial applications. The course covers multi-variable control, predictive control, adaptive control, and intelligent control techniques used in modern industries such as chemical, petrochemical, pharmaceutical, and manufacturing.

Course Objectives:

1. To provide a deep understanding of advanced control strategies in industrial processes.
2. To introduce model-based predictive control and its industrial applications.
3. To familiarize students with multivariable control and decentralized control techniques.
4. To explore adaptive and intelligent control systems for complex industrial processes.
5. To introduce optimization techniques used in process control.
6. To equip students with the knowledge to implement APC in real-time industrial systems.

Course Outcomes:

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

1. Understand and implement advanced control strategies for industrial processes.
2. Design and analyze model predictive control (MPC) systems.
3. Apply multivariable and decentralized control techniques in complex processes.
4. Utilize adaptive and intelligent control methods for process automation.
5. Develop optimization algorithms for efficient process control.
6. Integrate APC techniques in real-world industrial applications.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of Process and project management.	**2**	--
I	**Introduction to Advanced Process**	Need for advanced control in industries.	**6**	**CO1**

	Control	Limitations of conventional PID control. Overview of advanced control techniques. Model-based control and optimization in industrial processes. Process modeling and identification.		
II	**Model-Based Predictive Control (MPC)**	Fundamentals of MPC. Mathematical formulation of predictive control. Dynamic matrix control (DMC) and generalized predictive control (GPC). Implementation of MPC in real-time systems. Case studies of MPC in industry.	**7**	**CO2**
III	**Multivariable Control & Decentralized Control**	Multivariable process interactions and loop decoupling. Relative gain array (RGA) and Niederlinski index. Design and implementation of decentralized control systems. Applications in process industries	**7**	**CO3**
IV	**Adaptive & Intelligent Control Systems**	Need for adaptive control. Self-tuning regulators and model reference adaptive control (MRAC). Fuzzy logic control and neural network-based control. Industrial applications of adaptive and intelligent control	**6**	**CO4**
V	**Optimization Techniques in Process Control**	Optimization objectives and constraints. Linear and nonlinear programming in process optimization. Dynamic optimization methods. Implementation of optimization algorithms in APC. Case studies in chemical and manufacturing industries.	**7**	**CO5**
VI	**Industrial Applications & Case Studies**	APC implementation in petrochemical, pharmaceutical, and power plants. Integration of APC with DCS and SCADA systems. APC in Industry 4.0 and smart manufacturing. Case studies of real-world applications	**4**	**CO6**

Text Books:

1. "Process Dynamics and Control" – Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp
2. "Advanced Process Control" – Brian Roffel, Ben Betlem
3. "Model Predictive Control: Theory, Computation, and Design" – James B. Rawlings, David Q. Mayne, Moritz Diehl
4. "Intelligent Control Systems with an Introduction to System of Systems Engineering" – Thrishantha Nanayakkara

References:

1. "Advanced Control Unleashed: Plant Performance Management for Optimum Benefit" – ISA
2. "Multivariable Feedback Control" – Sigurd Skogestad, Ian Postlethwaite
3. "Adaptive Control" – Karl J. Åström, Björn Wittenmark

4. "Neural Networks for Control" – W. Thomas Miller, Richard S. Sutton, Paul J. Werbos

Online References:

Website Name
1. International Society of Automation (ISA) – Latest updates on APC techniques. 2. Control Engineering – Industrial applications of process control. 3. MathWorks (MATLAB for Control) – MATLAB resources for process control.

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL3012	Advanced Process Control Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL3012	Advanced Process Control Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To familiarize students with advanced process control techniques through practical experiments.
2. To implement model-based predictive control (MPC) and adaptive control strategies.
3. To analyze multivariable control and decentralized control techniques.
4. To develop optimization algorithms for process control applications.
5. To integrate advanced control strategies with industrial systems and real-time simulations.
6. To evaluate the performance of advanced controllers in dynamic process environments.

Lab Outcomes:

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

1. Design and implement advanced process control strategies.
2. Develop and test model predictive control algorithms for industrial processes.
3. Apply multivariable and decentralized control methods in real-time scenarios.
4. Utilize optimization techniques for improved process performance.
5. Integrate advanced controllers into industrial automation platforms.
6. Analyze real-time case studies and interpret control system performance.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite		02	
I	**Introduction to Advanced Process Control**	Understanding advanced control loops in process industries Implementation of feedforward and cascade control systems Hands-on with industrial process control trainers	**04**	**LO1**
II	**Model Predictive Control (MPC)**	Introduction to MPC and its applications. Design of dynamic models for predictive control. Tuning of MPC parameters	**04**	**LO2**
III	**Multivariable and Decentralized Control**	Multivariable interactions and loop decoupling techniques. Relative Gain Array (RGA) analysis. Decentralized control design	**04**	**LO3**
IV	**Adaptive and Intelligent Control Systems**	Self-tuning regulators and model reference adaptive control. Fuzzy logic-based process control. Neural network-based process control	**04**	**LO4**
V	**Optimization Techniques in Process Control**	Linear and nonlinear process optimization. Genetic algorithms and particle swarm optimization for process control. Real-time optimization using industrial controllers	**04**	**LO5**
VI	**Industrial Applications & Case Studies**	APC implementation in process industries. Case studies on chemical, petrochemical, and power plants. Integration of APC with DCS and SCADA	**04**	**LO6**

Text Books:

1. "Process Dynamics and Control" – Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp
2. "Advanced Process Control" – Brian Roffel, Ben Betlem
3. "Model Predictive Control: Theory, Computation, and Design" – James B. Rawlings, David Q. Mayne, Moritz Diehl

4. "Intelligent Control Systems with an Introduction to System of Systems Engineering" – Thrishantha Nanayakkara

References:

1. "Advanced Control Unleashed: Plant Performance Management for Optimum Benefit" – ISA
2. "Multivariable Feedback Control" – Sigurd Skogestad, Ian Postlethwaite
3. "Adaptive Control" – Karl J. Åström, Björn Wittenmark
4. "Neural Networks for Control" – W. Thomas Miller, Richard S. Sutton, Paul J. Werbos

Online Resources:

Website Name
1. International Society of Automation (ISA) – Latest updates on APC techniques. 2. Control Engineering – Industrial applications of process control. 3. MathWorks (MATLAB for Control) – MATLAB resources for process control. 4. IEEE Xplore – Research papers and case studies on advanced process control.

List of Experiments.

Sr No	List of Experiments	Hrs
01	Study of single-loop and multi-loop control systems using simulation tools.	02
02	Implementing Model Predictive Control for a chemical process using MATLAB.	02
03	Case study: Application of MPC in temperature control.	02
04	Implementation of multivariable control strategies for a coupled-tank system.	02
05	RGA-based design of a decentralized control system.	02
06	Implementation of adaptive control for a dynamic process system.	02
07	Fuzzy logic control for a process plant using MATLAB/Simulink.	02
08	Application of optimization techniques in PID tuning using genetic algorithms.	02
09	Real-time optimization of a heat exchanger control system.	02
10	Simulation of an industrial control system using SCADA.	02
11	Case study: MPC implementation in real-world industrial processes.	02

Sr No	List of Assignments / Tutorials	Hrs
01	Literature review on advanced process control techniques.	02
02	Analysis and comparison of PID and MPC in industrial applications.	02
03	Report on real-time implementation of adaptive control systems.	02
04	Simulation-based study on multivariable process control.	02
05	Development of an optimization algorithm for a chemical process.	02
06	Industrial case study analysis on the implementation of APC.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE3013	Robotics for Industrial Automation	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE3013	Robotics for Industrial Automation	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course provides an in-depth understanding of robotics and its application in industrial automation. It covers key concepts such as robot kinematics, dynamics, control systems, programming, and integration with industrial automation processes. The course also explores real-world applications in manufacturing, material handling, and assembly lines, along with modern trends such as collaborative robots and AI-driven automation.

Course Objectives:

1. To introduce the fundamentals of industrial robotics and automation.
2. To analyze the kinematics and dynamics of robotic systems.
3. To study various control strategies used in robotic automation.
4. To familiarize students with robotic programming and simulation.
5. To explore industrial applications of robotics in manufacturing and automation.
6. To discuss advancements in AI, IoT, and Industry 4.0 in robotics.

Course Outcomes:

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

1. Understand the basic principles and components of industrial robotics.
2. Model and analyze the kinematics and dynamics of robotic manipulators.
3. Implement various control strategies for precise robotic movement.
4. Develop and simulate robotic programs for industrial tasks.
5. Integrate robotic systems into automated industrial environments.
6. Evaluate modern trends and emerging technologies in industrial robotics.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of Robotics & automation.	**2**	--
I	**Introduction to Robotics and Industrial Automation**	History and evolution of robotics Basics of industrial automation and robotics Components of robotic systems (actuators, sensors, controllers) Classification of robots (serial, parallel, mobile robots) Degrees of freedom and workspace	**6**	**CO1**
II	**Kinematics and Dynamics of Industrial Robots**	Forward and inverse kinematics Jacobian and velocity kinematics Robot dynamics (Newton-Euler and Lagrange methods) Trajectory planning and path generation Case studies of kinematic analysis	**7**	**CO2**
III	**Robot Control Systems**	Types of robotic control (position, force, hybrid control) PID control and model-based control strategies Adaptive and intelligent control for robotics Motion control techniques in industrial robots Implementation of controllers using MATLAB/Simulink	**7**	**CO3**
IV	**Robot Programming and Simulation**	Offline and online programming methods Robot Operating System (ROS) Programming languages for robotics (Python, C++, RAPID, VAL) Industrial robot programming tools (ABB, FANUC, KUKA, Yaskawa) Simulation software (RoboDK, Gazebo, MATLAB)	**6**	**CO4**
V	**Industrial Applications of Robotics**	Robotics in manufacturing, assembly, material handling. Welding, painting, and packaging automation. Collaborative robots (Cobots) and human-robot interaction. Mobile robots and AGVs in warehouses. Case studies on robotic automation in industries	**7**	**CO5**
VI	**Advanced Trends in Robotics and**	Industry 4.0 and smart manufacturing. AI and machine	**4**	**CO6**

	Automation	learning in robotics. Internet of Things (IoT) in robotic automation Digital twins and virtual commissioning. Ethical and safety considerations in robotics		

Text Books:

1. "Introduction to Robotics: Mechanics and Control" – John J. Craig
2. "Robotics: Modelling, Planning and Control" – Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani
3. "Industrial Robotics: Technology, Programming, and Applications" – Mikell P. Groover
4. "Springer Handbook of Robotics" – Bruno Siciliano, Oussama Khatib

References:

1. "Fundamentals of Robotics: Analysis and Control" – Robert J. Schilling
2. "Robot Modeling and Control" – Mark W. Spong, Seth Hutchinson, M. Vidyasagar
3. "Artificial Intelligence for Robotics" – Francis X. Govers
4. "Robotic Systems and Autonomous Platforms" – Shawn M. Walsh, Michael S. Strano

Online References:

Website Name
1. Robot Operating System (ROS) – Open-source robotics software. 2. IEEE Robotics & Automation Society – Research publications and latest developments. 3. MathWorks Robotics – MATLAB tools for robotics simulation. 4. Coursera - Robotics Specialization – Online courses from top universities.

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

- A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL3013	Robotics for Industrial Automation Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL3013	Robotics for Industrial Automation Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide hands-on experience in robotic system programming and control.
2. To familiarize students with industrial robotic arms and automation tools.
3. To develop skills in robotic simulation and trajectory planning.
4. To implement real-time robotic control using microcontrollers and PLCs.
5. To integrate robotics with IoT and AI for smart automation.
6. To explore industrial applications of robotics in manufacturing and logistics.

Lab Outcomes:

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

1. Program and control industrial robotic arms using different programming methods.
2. Analyze and implement forward and inverse kinematics for robotic manipulators.
3. Use robotic simulation tools for path planning and automation.
4. Develop and integrate robotic systems with sensors and controllers.
5. Apply robotic control for real-world industrial applications.
6. Understand the role of AI and IoT in robotic automation.

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of IoT	02	
I	**Introduction to Industrial Robotics**	Basics of industrial robots and automation. Types and applications of robots in industries. Industrial robot components: actuators, sensors, controllers, and end effectors. Safety standards in industrial robotics.	**04**	**LO1**
II	**Kinematics and Dynamics of Robots**	Forward and inverse kinematics concepts. Robot trajectory planning and motion analysis. Dynamics of robotic manipulators. Implementation of kinematic solutions in simulation tools.	**04**	**LO2**
III	**Robot Control Systems**	PID control, model-based control, and adaptive control. Motion planning and force control strategies. Robot control using microcontrollers (Arduino, Raspberry Pi). PLC-based robotic control systems.	**04**	**LO3**
IV	**Industrial Robotic Programming**	Offline and online programming techniques. Programming languages for robotics (Python, C++, RAPID, VAL). Industrial robot programming using ABB, FANUC, KUKA, and Yaskawa. Simulation tools (RoboDK, Gazebo, MATLAB).	**04**	**LO4**
V	**Industrial Applications of Robotics**	Robotics in manufacturing, assembly, and material handling. Welding, painting, and packaging automation. Quality control and inspection using robotic vision. Mobile robots and autonomous guided vehicles (AGVs).	**04**	**LO5**
VI	**Advanced Topics in Robotics and IoT Integration**	AI and machine learning in robotics. IoT-enabled robotic systems and data analytics. Digital twins and cyber-physical systems in automation. Collaborative robots (Cobots) and human-robot	**04**	**LO6**

		interaction.		

Text Books:

1. "Introduction to Robotics: Mechanics and Control" – John J. Craig
2. "Industrial Robotics: Technology, Programming, and Applications" – Mikell P. Groover
3. "Robotics: Modelling, Planning and Control" – Bruno Siciliano, Lorenzo Sciavicco
4. "Springer Handbook of Robotics" – Bruno Siciliano, Oussama Khatib

References:

1. "Robot Modeling and Control" – Mark W. Spong, Seth Hutchinson
2. "Fundamentals of Robotics: Analysis and Control" – Robert J. Schilling
3. "Artificial Intelligence for Robotics" – Francis X. Govers
4. "Robotic Systems and Autonomous Platforms" – Shawn M. Walsh

Online Resources:

Website Name
1. Robot Operating System (ROS) – Open-source robotics platform. 2. IEEE Robotics & Automation Society – Research papers and latest developments. 3. MathWorks Robotics – MATLAB tools for robotics simulation. 4. Coursera - Robotics Specialization – Online courses from top universities.

List of Experiments.

Sr No	List of Experiments	Hrs
01	Introduction to robotic hardware and software environments.	02
02	Safety procedures and calibration of industrial robots.	02
03	Programming basics using industrial robot controllers (ABB, FANUC, KUKA).	02
04	Forward kinematics implementation using MATLAB/Python.	02
05	Inverse kinematics solution for a robotic arm.	02
06	Trajectory planning and motion control using RoboDK.	02
07	Implementing PID control for robotic joints.	02

08	Motion control using microcontrollers (Arduino/Raspberry Pi).	02
09	Adaptive and force control applications in industrial robots.	02
10	Offline programming of robots using simulation tools.	02
11	Real-time control and automation using PLC and SCADA.	02
12	Path optimization and speed control in robotic arms.	02
13	Pick and place operation using a robotic arm.	02
14	Assembly automation using multiple robots.	02
15	Quality inspection using vision-guided robotics.	02
16	AI-based object recognition for robotic automation.	02
17	IoT-enabled robotic monitoring and data analysis.	02
18	Human-robot collaboration using collaborative robots (Cobots).	02

Sr No	List of Assignments / Tutorials	Hrs
01	Simulation of a robotic arm performing pick-and-place operations.	02
02	Implementing kinematic analysis for a 6-DOF robotic manipulator.	02
03	Design and programming of a robotic control system using PID control.	02
04	PLC-based control implementation for robotic automation.	02
05	AI-based object recognition for robotic quality inspection.	02
06	Integration of an industrial robot with IoT for smart manufacturing.	02

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC401	Cyber-Physical Product Design for Robotics & Automation	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC401	Cyber-Physical Product Design for Robotics & Automation	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course provides a comprehensive understanding of designing and developing Cyber-Physical Systems (CPS) in the context of robotics and automation. It combines mechanical design, electronics, embedded systems, and networked control with software intelligence to build real-time integrated systems for automation.

Course Objectives:

1. To understand the fundamentals of cyber-physical systems and their role in automation and robotics.
2. To explore system modeling and co-design approaches for CPS.
3. To design and simulate embedded systems for real-time robotics applications.
4. To integrate sensors, actuators, and controllers into intelligent physical systems.
5. To develop communication strategies and safety-critical design principles.
6. To apply theoretical knowledge in practical experiments and project-based learning.

Course Outcomes:

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

1. Analyze CPS design requirements for automation and robotics applications.
2. Apply embedded system and mechatronics knowledge in system co-design.

3. Design real-time control systems integrated with sensor networks.
4. Develop prototypes of cyber-physical systems with appropriate hardware/software interfaces.
5. Evaluate system performance and safety using simulation tools.
6. Engage in interdisciplinary CPS projects applying modern engineering tools.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of Robotics & automation.	**2**	--
I	**Introduction to Cyber-Physical Systems**	• Definition, architecture, components • Applications in robotics, healthcare, automotive, and manufacturing • Interdisciplinary nature of CPS	**6**	**CO1**
II	**System Modeling and Co-Design**	• Modeling physical systems and digital control • Co-simulation using tools like MATLAB/Simulink, Modelica • Hybrid system modeling	**7**	**CO2**
III	**Embedded Systems for CPS**	• Microcontrollers and RTOS • Sensor and actuator integration • Energy-aware computing •	**7**	**CO3**
IV	**Communication and Networking in CPS**	• Wired and wireless communication protocols (CAN, MQTT, OPC-UA, ROS) • Real-time data acquisition and control • IoT in CPS and edge computing	**6**	**CO4**
V	**Control and Automation**	• Real-time control for robotic systems • Control and Automation • Integration of AI and ML for adaptive automation	**7**	**CO5**

VI	**Safety, Security, and Case Studies**	• Cybersecurity for CPS • Fault detection and recovery • Case studies in industrial automation and robotic products	**4**	**CO6**

Text Books:

1. Edward A. Lee and Sanjit A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach," MIT Press
2. Raj Rajkumar, "Cyber-Physical Systems," Pearson Education
3. Alok Sinha, "Linear Systems: Optimal and Robust Control," CRC Press

References:

1. Peter Marwedel, "Embedded System Design," Springer
2. Raj Madhavan, "Robotics and Automation Handbook," CRC Press
3. Rajiv Mall, "Real-Time Systems: Theory and Practice," Pearson

Online References:

Website Name
1. https://ocw.mit.edu (MIT CPS Courseware) 2. https://nptel.ac.in (NPTEL Robotics & Embedded Systems) 3. https://www.coursera.org (Courses on CPS, Robotics, and Automation) 4. https://www.mathworks.com (MATLAB for CPS and embedded systems) 5. https://github.com (CPS and embedded system repositories)

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

- Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

- A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPC402	Reinforcement Learning & Control in Robotics	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPC402	Reinforcement Learning & Control in Robotics	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course introduces students to the foundational and advanced techniques in reinforcement learning (RL) and its applications in robotic control systems. The course integrates concepts from machine learning, control theory, and robotics to develop intelligent systems capable of decision-making and adaptation in dynamic environments.

Course Objectives:

1. To understand the fundamentals of reinforcement learning and its mathematical foundations.
2. To explore policy-based and value-based RL methods.
3. To implement RL algorithms in robotic control tasks.
4. To integrate RL with control theory for optimal decision-making.
5. To analyze the performance of RL-based control systems in dynamic environments.
6. To apply RL to real-world robotics scenarios such as path planning, manipulation, and navigation.

Course Outcomes:

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

1. Formulate robotic problems as reinforcement learning tasks.
2. Implement and tune various RL algorithms including Q-learning, SARSA, DDPG, PPO.
3. Integrate RL with classical control techniques.
4. Simulate and analyze the performance of RL algorithms using OpenAI Gym, ROS, or Gazebo.
5. Apply deep reinforcement learning for complex robotic environments.
6. Design intelligent robotic systems capable of learning and adapting in real-time.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of AI.	**2**	--
I	**Introduction to RL and Control Systems**	• Basics of reinforcement learning • Agent-environment interaction • Classical control vs. learning-based control	**6**	**CO1**
II	**Markov Decision Processes (MDP)**	• MDP formulation • Bellman equations • Policy evaluation and improvement	**7**	**CO2**
III	**Model-Free RL Algorithms**	• Monte Carlo methods • Temporal Difference (TD) learning • Q-learning and SARSA	**7**	**CO3**
IV	**Policy Gradient and Actor-Critic Methods**	• Policy gradient theorem • REINFORCE algorithm • Actor-Critic, A3C	**6**	**CO4**
V	**Deep Reinforcement Learning**	• Deep Q-Network (DQN) • DDPG, TD3, PPO, SAC • Exploration strategies and reward engineering	**7**	**CO5**

VI	**RL in Robotics**	• RL integration with ROS/Gazebo • Path planning, grasping, and manipulation • Multi-agent RL and real-time challenges	**4**	**CO6**

Text Books:

1. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction," MIT Press
2. M. Wiering and M. van Otterlo, "Reinforcement Learning: State-of-the-Art," Springer
3. S. Russell and P. Norvig, "Artificial Intelligence: A Modern Approach," Pearson

References:

1. Pieter Abbeel and John Schulman, "Deep Reinforcement Learning Course Notes"
2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "Deep Learning," MIT Press
3. Karl J. Åström and Richard M. Murray, "Feedback Systems: An Introduction for Scientists and Engineers," Princeton University Press

Online References:

Website Name
1. https://spinningup.openai.com (OpenAI Spinning Up in Deep RL) 2. https://gym.openai.com (OpenAI Gym Documentation) 3. https://nptel.ac.in/courses (NPTEL AI & Robotics Courses) 4. https://course.fast.ai (Practical Deep Learning Resources) 5. https://github.com/dennybritz/reinforcement-learning (Popular RL Algorithm Implementations)

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPARP401	Research Project	Entire Semester			6	-	-	6

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPARP401	Research Project	--	--	--	--	--	200	100	300

Research Project Guidelines for M.Tech Courses

1. Introduction The M.Tech research project is a crucial component of the curriculum, designed to encourage innovation, critical thinking, and problem-solving skills. This document provides guidelines for planning, executing, and evaluating research projects.

2. Objectives

- To develop research-oriented thinking and technical expertise.
- To apply theoretical knowledge to solve real-world engineering problems.
- To enhance skills in research methodology, experimentation, and technical writing.

3. Eligibility

- Students must have completed at least one semester of the M.Tech program.
- Research topics should be aligned with the student's area of specialization.

4. Project Selection

- Students should choose a research topic in consultation with their faculty advisor.
- The topic must be innovative, feasible, and contribute to the advancement of knowledge.
- A formal project proposal must be submitted and approved by the department.

5. Research Methodology

- Define clear research objectives and hypotheses.
- Conduct a thorough literature review to understand the current state of research.
- Choose appropriate research methods (experimental, computational, analytical, etc.).

- Maintain a structured timeline with milestones for progress tracking.

6. Supervision & Mentorship

- Each student will be assigned a faculty guide by HoD for guidance and evaluation.
- Regular meetings with the guide should be scheduled to discuss progress.
- Industry collaboration is encouraged for applied research projects.

7. Documentation & Reporting

- Maintain a research journal/logbook documenting progress and challenges.
- Prepare periodic progress reports as per university guidelines.
- Submit a mid-term review report for evaluation.
- The final research report should include:
  - Abstract
  - Introduction & Literature Review
  - Methodology
  - Experimental Results/Findings
  - Conclusion & Future Scope
  - References

8. Evaluation Criteria

- Research quality and originality (30%)
- Methodology and technical rigor (30%)
- Documentation and report quality (20%)
- Presentation and viva-voce (20%)

9. Code of Conduct & Ethics

- Maintain academic integrity and avoid plagiarism.
- Follow ethical research practices, including data confidentiality.
- Any misconduct may result in academic penalties.

10. Important Deadlines

- Submission of research project proposal for sem III and sem IV: One Week before the Semester Start to the college department.
- Mid-term evaluation: Two review need to be conducted by the department: 1st review in 2nd week after semester start and then 2nd review between 8th to 10th week of the semester.
- Final report submission: as per term work submission date of UoM.
- Viva-voce & presentation: as per UoM policies.

For above details, students should consult their department's coordinator.

Assessment :

Term Work: Term Work shall consist of at least 10 to 12 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 100 Marks (Total marks) = 70 Marks (Research) + 25 Marks (Report) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above Research Project.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE4011	CNC Robotics and Intelligent Machining	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE4011	CNC Robotics and Intelligent Machining	20	20	40	60	2	--	--	100

COURSE OVERVIEW: This course provides an in-depth understanding of the integration of

CNC (Computer Numerical Control) technology with robotics and intelligent manufacturing systems. Students will explore the evolution of CNC systems, robotic interfaces, intelligent decision-making, and automation strategies for smart machining applications.

Course Objectives:

1. To understand the fundamentals of CNC systems and robotic integration.
2. To study CNC programming, machine kinematics, and post-processing for automation.
3. To explore robotic control for machining, handling, and inspection tasks.
4. To introduce AI techniques for process optimization and adaptive machining.
5. To analyze system-level architecture for smart manufacturing environments.
6. To apply digital twin and Industry 4.0 concepts in CNC and robotic systems.

Course Outcomes:

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

1. Develop CNC programs for 3 to 5 axis machining operations.
2. Integrate robots with CNC machines for material handling and tool changing.
3. Analyze and model the kinematics of CNC and robotic systems.

4. Apply intelligent control and optimization techniques for real-time machining.
5. Design automation systems using industrial sensors and vision systems.
6. Employ digital simulation tools to create a digital twin for CNC robotics.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of Robotics.	**2**	--
I	**Introduction to CNC and Robotics**	• Basics of CNC machining: G-code, M-code, tool paths • Robotic systems and types of robots • Overview of integration in manufacturing	**6**	**CO1**
II	**CNC Machine Kinematics and Programming**	• 3-axis and 5-axis CNC kinematics • Interpolation methods • CAM software and post-processors	**7**	**CO2**
III	**Robotic Integration with CNC**	• Robot arms for loading/unloading • Tool changers and spindle interfacing • Synchronization and controller communication	**7**	**CO3**
IV	**Sensors and Vision Systems**	• Integration of tactile, proximity, and vision sensors • In-process measurement and inspection • Adaptive control based on sensor feedback	**6**	**CO4**
V	**Intelligent Machining**	• AI/ML in machining: predictive maintenance, adaptive feedrate • Process planning and real-time decision making • Edge computing in CNC environments	**7**	**CO5**

VI	**Digital Twin and Industry 4.0 Applications**	• Simulation and virtualization of machining systems • Cyber-Physical Systems (CPS) • IoT, Cloud, and data analytics in smart machining	**4**	**CO6**

Text Books:

1. Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing," Pearson
2. Yoram Koren, "Computer Control of Manufacturing Systems," McGraw-Hill
3. J. Norberto Pires, "Industrial Robots Programming: Building Applications for the Factories of the Future," Springer

References:

1. Paul E. Mix, "Introduction to Robotics in CIM Systems," Prentice Hall
2. H. Chang and R. Ko, "Intelligent Machining," Springer
3. Peter Smid, "CNC Programming Handbook," Industrial Press Inc.

Online References:

Website Name
1. https://www.nptel.ac.in (NPTEL CNC, Robotics, and Automation Courses) 2. https://www.autodesk.com (Fusion 360 for CAM and CNC simulation) 3. https://www.robotics.org (RIA – Robotic Industries Association) 4. https://www.youtube.com/user/HaasAutomationInc (CNC tutorials and demos) 5. https://github.com (Open-source CNC and robotics projects)

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE4012	AI-Driven Process Control & Automation	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE4012	AI-Driven Process Control & Automation	20	20	40	60	2	--	--	100

COURSE OVERVIEW: This course explores the integration of Artificial Intelligence (AI) with modern process control systems for industrial automation. It focuses on intelligent decision-making, predictive control, optimization, and system learning to enhance reliability, efficiency, and autonomy of automated processes.

Course Objectives:

1. To introduce the principles of process control and automation.
2. To familiarize students with AI techniques such as machine learning and deep learning.
3. To demonstrate how AI can be integrated into process monitoring, fault detection, and control.
4. To explore advanced control strategies like adaptive and predictive control enhanced by AI.
5. To enable data-driven modeling and control in real-time environments.
6. To prepare students for implementing AI-based solutions in industrial automation.

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

1. Understand and analyze conventional and AI-based process control architectures.
2. Apply machine learning techniques to model dynamic processes.
3. Design intelligent control systems using neural networks and fuzzy logic.
4. Implement predictive maintenance and anomaly detection using AI algorithms.
5. Integrate AI with industrial protocols and real-time systems.
6. Evaluate the performance of AI-enhanced automation systems using case studies.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of AI.	**2**	--
I	**Fundamentals of Process Control & Automation**	• Control system architectures • Sensors, actuators, PLCs, SCADA • Challenges in modern automation	**6**	**CO1**
II	**Introduction to AI and Machine Learning**	• Supervised, unsupervised, and reinforcement learning • Data preprocessing and feature engineering • Regression, classification, clustering techniques	**7**	**CO2**

III	**Neural Networks and Deep Learning**	• Feedforward and recurrent neural networks • CNNs for image-based inspection • Autoencoders and LSTM networks for time-series data	**7**	**CO3**
IV	**Intelligent Control Systems**	• Fuzzy logic control • Neuro-fuzzy systems • Adaptive and self-tuning control	**6**	**CO4**
V	**Predictive Analytics and Fault Detection**	• Predictive maintenance using AI • Model predictive control (MPC) with ML enhancements • Anomaly detection in process variables	**7**	**CO5**
VI	**Industrial Implementation and Case Studies**	• AI tools and frameworks (TensorFlow, PyTorch, Scikit-learn) • Integration with PLCs, OPC UA, MQTT • Case studies in chemical, manufacturing, and energy sectors	**4**	**CO6**

Text Books:

1. Stephanopoulos G., "Chemical Process Control," Prentice Hall
2. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach," Pearson
3. S. Sumathi and S. Esakkirajan, "Fundamentals of Neural Networks," Springer

References:

1. Kevin Warwick, "Artificial Intelligence in Industrial Decision Making, Control and Automation," Butterworth-Heinemann
2. Karray & Silva, "Soft Computing and Intelligent Systems Design," Pearson
3. B. Wayne Bequette, "Process Control: Modeling, Design, and Simulation," Prentice Hall

Online References:

Website Name
1. https://nptel.ac.in (Courses on Process Control, AI, and ML) 2. https://ocw.mit.edu (MIT OCW for Control and AI Systems) 3. https://scikit-learn.org (Machine Learning in Python) 4. https://www.tensorflow.org (AI & Deep Learning Framework) 5. https://www.mathworks.com (MATLAB for Control and Machine Learning)

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**
  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPE4013	Advanced Robotics for Industrial Automation	3	-	-	3	-	-	3

Course Code	Course Name	Theory					Term work	Pract / Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		IA-I	IA-II	IA-I + IA-II					
RPAPE4013	Advanced Robotics for Industrial Automation	20	20	40	60	2	--	--	100

COURSE OVERVIEW:

This course explores the advanced principles and practices of robotics as applied to industrial automation. It includes robot kinematics and dynamics, sensor integration, AI-based robot control, robotic vision, and the development of autonomous and collaborative robotic systems tailored for manufacturing and production environments.

Course Objectives:

1. To understand advanced kinematics and dynamics of robotic manipulators.
2. To integrate various types of sensors and actuators in robotic systems.
3. To explore intelligent control strategies using AI and machine learning.
4. To develop path planning and motion control algorithms for autonomous robots.
5. To study robotic vision and object recognition techniques.
6. To design and analyze collaborative and mobile robotic systems for industrial applications.

Course Outcomes:

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

1. Analyze and model complex robotic mechanisms.
2. Integrate perception and sensor systems into robotic platforms.
3. Implement adaptive and intelligent control algorithms in real-time.

4. Design vision-based robotic systems for object tracking and navigation.
5. Develop collaborative robotic applications with safety considerations.
6. Simulate, prototype, and validate robotics solutions in industrial environments.

DETAILED SYLLABUS:

Sr. No.	Name of Module	Detailed Content	Hours	CO Mapping
0	Prerequisite	Basic of Robotics.	**2**	--
I	**Robot Kinematics and Dynamics**	• Forward and inverse kinematics • Jacobians, velocity, and force analysis • Dynamic modeling using Euler-Lagrange equations	**6**	**CO1**
II	**Sensors and Actuators in Robotics**	• Types of sensors: proximity, vision, force/torque, IMU • Actuators: servo motors, stepper motors, pneumatic and hydraulic drives • Sensor-actuator integration and calibration	**7**	**CO2**
III	**Robotic Control Systems**	• PID, adaptive and impedance control • Trajectory tracking • Introduction to ROS and real-time robot programming	**7**	**CO3**
IV	**AI and Machine Learning in Robotics**	• Supervised and reinforcement learning for robotic control • Neural networks for decision-making and motion prediction • AI for fault detection and failure analysis	**6**	**CO4**
V	**Robotic Vision and Perception**	• Image acquisition, filtering, and segmentation • Object detection and tracking • Depth sensing, stereo vision,	**7**	**CO5**

		and SLAM		
VI	**Collaborative and Mobile Robotics**	• Human-robot interaction (HRI) • Multi-robot coordination • Safety and standards in industrial robotics (ISO 10218)	**4**	**CO6**

Text Books:

1. John J. Craig, "Introduction to Robotics: Mechanics and Control," Pearson
2. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications," Wiley
3. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms," Springer

References:

1. Siciliano & Khatib, "Springer Handbook of Robotics," Springer
2. Richard D. Klafter et al., "Robotic Engineering: An Integrated Approach," Prentice Hall
3. Oussama Khatib, "Robotics Research," Springer

Online References:

Website Name
1. https://ros.org (Robot Operating System) 2. https://nptel.ac.in (NPTEL Robotics & Control Systems) 3. https://ocw.mit.edu (MIT OCW – Robotics Courses) 4. https://opencv.org (OpenCV for Robotic Vision) 5. https://www.mathworks.com (MATLAB Robotics Toolbox)

Assessment:

Internal Assessment Test (IAT) for 20 marks each:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of the syllabus content must be covered in the IAT-I and the remaining 40% to 50% of the syllabus content must be covered in the IAT-II.

End Semester Theory Examination:

- **Question paper format**

  - Question Paper will comprise a total of **six questions each carrying 15 marks Q.1** will be **compulsory** and should **cover the maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL401	Cyber-Physical Product Design Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL401	Cyber-Physical Product Design Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide hands-on experience in designing cyber-physical systems (CPS)
2. To develop skills in integrating sensors, actuators, and embedded controllers
3. To implement real-time data acquisition and processing
4. To familiarize students with wireless communication and cloud connectivity
5. To build prototype models for smart systems and products
6. To foster interdisciplinary collaboration in design and development

Lab Outcomes:

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

1. Design functional prototypes of cyber-physical systems
2. Integrate sensing, control, and computation in real-time applications
3. Utilize microcontrollers and IoT platforms for CPS implementation
4. Perform system validation and optimization
5. Develop connected devices with edge/cloud interfaces
6. Demonstrate working knowledge in safety, reliability, and product scalability

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of Embedded, C/Python Programming and IoT.	02	
I	**Introduction to CPS Lab Framework**	• CPS concepts and architecture • Hardware/software development environments	**04**	**LO1**
II	**Embedded Systems for CPS**	• Microcontroller interfacing (Arduino, Raspberry Pi, ESP32) • Real-time operating systems and interrupt handling	**04**	**LO2**
III	**Sensor and Actuator Integration**	• Data acquisition techniques • Motor drivers, relays, and actuator control	**04**	**LO3**
IV	**Communication Protocols and IoT**	• I2C, SPI, UART, MQTT, HTTP • Connecting to the cloud (ThingSpeak, AWS IoT)	**04**	**LO4**
V	**Data Processing and Control Logic**	• Signal filtering and decision-making algorithms • Rule-based and AI-based automation	**04**	**LO5**
VI	**System Testing, Deployment, and Case Studies**	• End-to-end testing of prototypes • Cybersecurity in CPS • Industrial and consumer product case studies	**04**	**LO6**

Text Books:

1. Edward A. Lee, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach," MIT Press
2. Rajeev Alur, "Principles of Cyber-Physical Systems," MIT Press
3. Jonathan Valvano, "Embedded Systems: Real-Time Interfacing to Arm Cortex-M Microcontrollers," CreateSpace

References:

1. Dieter Uckelmann, Mark Harrison, "Architecting the Internet of Things," Springer
2. Mohammad Ali Mazidi, "The 8051 Microcontroller and Embedded Systems," Pearson
3. William Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering," Pearson

Online Resources:

Website Name
1. https://nptel.ac.in/courses/108108111 (Embedded Systems & CPS) 2. https://www.arduino.cc (Arduino project documentation) 3. https://www.raspberrypi.org (Raspberry Pi tutorials) 4. https://thingspeak.com (IoT cloud platform) 5. https://cps-vo.org (Cyber-Physical Systems Virtual Organization) 6. https://www.blynk.io (IoT dashboard and mobile app platform)

List of Experiments.

1. Interfacing temperature and humidity sensors to microcontrollers
2. Actuator control using PWM and H-bridge circuits
3. Wi-Fi-based sensor data transmission to cloud platforms
4. Real-time dashboard creation using Blynk or ThingSpeak
5. IoT-based home automation system prototype
6. Vibration monitoring and predictive maintenance setup
7. Smart irrigation system design
8. Object detection with ultrasonic or PIR sensors

List of Assignments:

1. Design a CPS model for smart home energy monitoring
2. Mini-project on smart wearable health monitoring device
3. Assignment on comparing cloud platforms for IoT (AWS, Azure, Blynk)
4. Analyze a CPS failure case and suggest design improvements
5. Assignment on sensor calibration and noise reduction techniques

6. Final capstone project: Full-stack CPS prototype for an industrial or consumer application

Assessment :

Term Work: Term Work shall consist of 8 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL402	Autonomous Robotics & Reinforcement Learning Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL402	Autonomous Robotics & Reinforcement Learning Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide practical experience in autonomous robotic system design
2. To implement and analyze reinforcement learning algorithms in robotic applications
3. To integrate perception, planning, and control in autonomous robots
4. To develop skills in simulation and real-time testing of autonomous behaviors
5. To explore policy-based and value-based learning approaches
6. To build full-cycle autonomous agents capable of task adaptation

Lab Outcomes:

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

1. Design autonomous robotic systems using ROS or similar platforms
2. Implement reinforcement learning algorithms for continuous control tasks
3. Apply perception techniques using camera or LIDAR inputs
4. Simulate real-world navigation and object manipulation scenarios
5. Evaluate policy learning algorithms under various environments
6. Prototype real-time autonomous agents with adaptive control

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of Maths, Python Programming.	02	
I	**Introduction to Autonomous Robotics Lab Tools**	• Overview of ROS, Gazebo, and Python frameworks • Setting up simulation environments	**04**	**LO1**
II	**Robot Control and Sensing**	• Motion control of differential drive and robotic arms • Interfacing sensors: IMU, cameras, LIDAR	**04**	**LO2**
III	**Reinforcement Learning Basics**	• Value iteration, policy iteration, Q-learning • Model-free vs model-based approaches	**04**	**LO3**
IV	**Deep Reinforcement**	• DQN, DDPG, PPO architectures	**04**	**LO4**

	Learning (DRL)	• Policy gradient methods		
V	**Task-Specific Robot Learning**	• Path planning and obstacle avoidance • Target following and localization	**04**	**LO5**
VI	**Deployment and Evaluation**	• Testing learned policies on physical or simulated robots • Metrics: convergence, reward, safety, success rate	**04**	**LO6**

Text Books:

1. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction," MIT Press
2. Dieter Fox, Wolfram Burgard, and Sebastian Thrun, "Probabilistic Robotics," MIT Press
3. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms," Springer

References:

1. Ian Goodfellow et al., "Deep Learning," MIT Press
2. Stefan Schaal et al., "Learning for Control from Demonstration and Practice," Springer
3. Jens Kober et al., "Reinforcement Learning in Robotics: A Survey," Springer

Online Resources:

Website Name
1. https://gym.openai.com (OpenAI Gym for RL environments) 2. https://www.ros.org (Robot Operating System) 3. https://github.com/ros-simulation/gazebo_ros_pkgs 4. https://spinningup.openai.com (OpenAI Spinning Up in Deep RL) 5. https://deeplearning.ai (Deep Learning courses and tools) 6. https://nptel.ac.in/courses/106105234 (NPTEL RL and Robotics lectures)

List of Experiments.

1. Differential drive robot simulation in Gazebo
2. Implementing Q-learning for maze solving

3. Object tracking using camera and deep Q-networks
4. Using PPO for robotic arm reaching tasks
5. LIDAR-based obstacle avoidance using RL
6. Policy evaluation and reward shaping analysis
7. Real-world deployment on TurtleBot or Jetson Nano robot
8. Sim-to-real transfer of a learned navigation policy

List of Assignments:

1. Assignment on setting up and customizing robot simulation environments
2. Coding Q-learning for grid-based environments
3. Comparison study of DQN vs DDPG in navigation tasks
4. Implementation of vision-based target approach behavior
5. Analytical write-up on the challenges of real-world RL
6. Final project: Multi-agent RL scenario (e.g., warehouse robots)

Assessment :

Term Work: Term Work shall consist of 8 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPCL403	Autonomous Systems Programming Lab	-	2*+2	-	-	2	-	2

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPCL403	Autonomous Systems Programming Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To impart hands-on programming experience for autonomous systems
2. To integrate sensors, actuators, and controllers in embedded platforms
3. To develop motion planning and control algorithms for autonomous systems
4. To simulate and implement autonomy in navigation and decision-making
5. To build applications for autonomous robotic and vehicular platforms
6. To expose students to industry-grade tools and protocols used in autonomous systems

Lab Outcomes:

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

1. Program autonomous systems for sensor acquisition and actuation
2. Implement real-time control and feedback mechanisms
3. Use ROS for modular and scalable development
4. Deploy and test autonomous systems in simulated and real environments
5. Integrate computer vision and AI for enhanced autonomy
6. Validate system performance against design requirements

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping

0	Prerequisite	Basic of C, Python Programming, OS, Microcontroller.	02	
I	**Programming Environment Setup**	• ROS installation and workspace setup • Version control and code repositories (Git)	**04**	**LO1**
II	**Sensor Interfacing and Data Processing**	• IMU, GPS, LIDAR, and camera modules • Sensor fusion and filtering techniques	**04**	**LO2**
III	**Motion Planning and Control Algorithms**	• PID control, trajectory generation • Obstacle avoidance and path optimization	**04**	**LO3**
IV	**Robot Perception and Decision Making**	• Visual and spatial recognition • Basic object detection and lane following	**04**	**LO4**
V	**Simulation and Deployment**	• Simulated environments in Gazebo or Webots • Sim-to-real deployment strategies	**04**	**LO5**
VI	**System Integration and Final Project**	• Full-stack autonomous system development • Evaluation metrics and performance analysis	**04**	**LO6**

Text Books:

1. Jason M. O'Kane, "A Gentle Introduction to ROS"
2. Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics," MIT Press
3. Peter Corke, "Robotics, Vision and Control," Springer

References:

1. Joseph Lentin, "Learning Robotics using Python," Packt Publishing
2. Aaron Martinez and Enrique Fernandez, "Learning ROS for Robotics Programming"
3. Brian Gerkey, "Programming Robots with ROS," O'Reilly

Online Resources:

Website Name
1. https://www.ros.org (Robot Operating System documentation) 2. https://github.com/ros (ROS packages and tutorials) 3. https://opencv.org (OpenCV computer vision library) 4. https://gazebosim.org (Gazebo robot simulation) 5. https://nptel.ac.in/courses/106105234 (NPTEL Robotics courses) 6. https://automaticaddison.com (ROS and robotics tutorials)

List of Experiments.

1. Writing ROS nodes for sensor data publishing and subscribing
2. Controlling a simulated TurtleBot using velocity commands
3. Implementing PID control for line following
4. Programming obstacle avoidance using LIDAR data
5. GPS-based navigation for outdoor robots
6. Image-based object tracking using OpenCV
7. Visual SLAM in Gazebo environment
8. Autonomous delivery robot simulation with multi-goal navigation

List of Assignments:

1. Code assignment on sensor fusion using Kalman filters
2. Design a path planning algorithm for dynamic environments
3. Real-time obstacle detection and response logic
4. ROS package creation for modular robot control
5. Capstone assignment: Integration of perception, planning, and actuation
6. Performance report comparing multiple planning strategies

Assessment :

Term Work: Term Work shall consist of 8 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL4011	CNC Robotics and Intelligent Machining Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL4011	CNC Robotics and Intelligent Machining Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To provide hands-on training in CNC programming and operations
2. To integrate robotics with CNC systems for automated machining
3. To explore sensor-based intelligent machining practices
4. To enhance precision and process optimization using AI/ML methods
5. To develop automated workflows using robot arms and CNC controllers
6. To apply IoT and digital twins in machining system monitoring

Lab Outcomes:

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

1. Generate and execute CNC codes for complex machining tasks
2. Interface robotic arms with CNC machines for hybrid operations
3. Utilize sensor feedback for real-time machining control
4. Implement AI/ML techniques for tool wear prediction and path optimization
5. Develop end-to-end machining workflows using CAM software
6. Monitor and analyze system performance using digital interfaces

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic Python/C Programming.	02	
I	**CNC Programming Basics**	• Manual and computer-aided programming • G-code and M-code fundamentals	**04**	**LO1**
II	**Robotic Integration with CNC**	• Robot arm programming for loading/unloading • Coordinated movement and safety interlocks	**04**	**LO2**
III	**Sensor-Assisted Machining**	• Tool condition monitoring • Spindle vibration and force analysis	**04**	**LO3**
IV	**AI in Intelligent Machining**	• Path optimization using machine learning • Predictive maintenance using sensor data	**04**	**LO4**
V	**Digital Twin and IoT Integration**	• Data acquisition and remote monitoring • Cloud-based analytics and dashboarding	**04**	**LO5**
VI	**Final Integration Project**	• End-to-end automation of machining cell • Evaluation on quality, accuracy, and productivity	**04**	**LO6**

Text Books:

1. Smid, Peter, "CNC Programming Handbook," Industrial Press Inc.
2. Craig, J.J., "Introduction to Robotics: Mechanics and Control," Pearson
3. Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing"

References:

1. Kundra, Rao, Tiwari, "Numerical Control and Computer Aided Manufacturing"
2. Fu, Gonzalez, and Lee, "Robotics: Control, Sensing, Vision, and Intelligence"
3. Norberto Pires, "Industrial Robotics: Programming, Simulation and Applications"

Online Resources:

Website Name
1. https://www.cncci.com 2. https://www.autodesk.com/products/fusion-360 3. https://www.ros.org 4. https://www.tutorialspoint.com/cnc_programming/index.htm 5. https://www.machinedesign.com 6. https://www.sciencedirect.com/topics/engineering/intelligent-machining

List of Experiments.

1. G-code programming for contour and pocket milling
2. CNC lathe operation for turning and threading
3. Robotic arm programming for automated part handling
4. Tool wear monitoring using vibration sensors
5. Implementation of real-time force feedback loop
6. Machine learning model for predicting tool replacement
7. IoT dashboard for real-time CNC monitoring
8. Full-cycle autonomous machining workflow

List of Assignments:

1. Design and simulate CNC toolpaths in CAM software
2. Robot-CNC workcell layout planning
3. Predictive analysis using vibration data
4. Integration of vision-based part detection
5. AI-driven process parameter tuning assignment
6. Capstone project documentation and presentation

Assessment :

Term Work: Term Work shall consist of 8 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL4012	AI-Driven Process Control & Automation Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				
RPAPEL4012	AI-Driven Process Control & Automation Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To introduce AI techniques in process control scenarios
2. To develop intelligent control strategies using machine learning
3. To apply predictive models for process optimization
4. To implement adaptive control systems for real-time operations
5. To integrate AI with traditional SCADA and PLC-based control systems
6. To analyze system performance using AI-based tools

Lab Outcomes:

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

1. Model and simulate process control systems integrated with AI
2. Implement neural networks and fuzzy logic for control optimization
3. Develop predictive maintenance models using process data
4. Create real-time AI-based controllers for automation tasks
5. Interface AI algorithms with PLC/SCADA systems
6. Evaluate and improve control strategies based on performance metrics

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of Python Programming.	02	
I	**Introduction to AI in Process Control**	• Overview of AI applications • Review of classical control vs AI-driven control	**04**	**LO1**
II	**AI Tools and Environments**	• Python libraries (TensorFlow, Scikit-learn, Keras) • MATLAB toolboxes for AI & control	**04**	**LO2**
III	**Machine Learning for Control Prediction**	• Supervised learning models for process prediction • Regression, decision trees, and time-series forecasting	**04**	**LO3**
IV	**Neural Networks and Fuzzy Logic**	• ANN and Fuzzy logic for intelligent control • Training and tuning neural controllers	**04**	**LO4**
V	**Reinforcement Learning and Adaptive Control**	• Basics of RL in automation • Implementing Q-learning for real-time control	**04**	**LO5**

VI	**System Integration and Performance Evaluation**	• Deploying AI models on simulated/real platforms • KPIs and benchmarking AI-based controllers	**04**	**LO6**

Text Books:

1. Kevin Warwick, "Artificial Intelligence in Industrial Control Systems"
2. Simon Haykin, "Neural Networks and Learning Machines"
3. Karl Johan Åström & Björn Wittenmark, "Adaptive Control"

References:

1. Mohan, C. K., "Machine Learning in Automation"
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications"
3. Bequette, B. Wayne, "Process Control: Modeling, Design, and Simulation"

Online Resources:

Website Name
1. https://scikit-learn.org 2. https://www.tensorflow.org 3. https://www.mathworks.com 4. https://nptel.ac.in/courses/112105249 5. https://towardsdatascience.com 6. https://www.controleng.com

List of Experiments.

1. Simulation of PID vs Neural Network controller
2. Predictive model for tank level control using ML
3. Implementation of fuzzy logic controller for temperature regulation
4. Real-time adaptive control of a heating system using Q-learning
5. Integration of Python-based ML model with SCADA via OPC-UA
6. Data preprocessing and feature selection from process datasets
7. Time-series analysis for process anomaly detection
8. Final project: AI-controlled multi-variable process simulation

List of Assignments:

1. Design a fuzzy logic system for pressure control

2. Train and test an ML model for fault classification in a reactor
3. Comparative study between PID and AI-based tuning
4. Deployment of AI model in MATLAB/Simulink for process control
5. Report on data-driven modeling using sensor data
6. Capstone assignment: End-to-end AI automation setup and evaluation

Assessment :

Term Work: Term Work shall consist of 8 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
RPAPEL4013	Advanced Robotics for Industrial Automation Lab	-	2	-	-	1	-	1

Course Code	Course Name	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		IA-I	IA-II	IA-I + IA-II				

RPAPEL4013	Advanced Robotics for Industrial Automation Lab	--	--	--	--	25	25	50

Lab Objectives:

1. To explore advanced robotic technologies used in industrial automation
2. To implement kinematic and dynamic models in real robotic systems
3. To develop and program industrial robots for automated operations
4. To integrate vision systems for intelligent robotic control
5. To simulate, test, and validate robotic workflows
6. To understand safety protocols and standards in industrial robotics

Lab Outcomes:

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

1. Configure and program industrial robots for automation tasks
2. Analyze robotic motion using forward and inverse kinematics
3. Integrate vision-based feedback in robotic systems
4. Apply AI for robotic perception and decision making
5. Evaluate robot performance for real-world tasks
6. Implement safe robotic workflows in manufacturing environments

DETAILED SYLLABUS

Sr. No.	Module	Detailed Content	Hours	LO Mapping
0	Prerequisite	Basic of Robotics , Python Programming.	02	
I	**Introduction to Advanced Industrial Robots**	• Types and applications • Architecture and working principles	**04**	**LO1**
II	**Kinematics and Dynamics in Industrial Robots**	• DH parameters, Forward and Inverse kinematics • Dynamics equations and motion control	**04**	**LO2**
III	**Robot Programming and Simulation**	• Online and offline programming • Simulation tools (e.g., RoboDK, ROS, MATLAB)	**04**	**LO3**

IV	**Vision and AI in Robotics**	• Vision-based part detection and manipulation • Object tracking and identification using AI	**04**	**LO4**
V	**Human-Robot Collaboration (HRC)**	• Safety design and protocols • Cobots and collaborative applications	**04**	**LO5**
VI	**Capstone Integration Project**	• Designing an automated robotic workstation • Performance testing and documentation	**04**	**LO6**

Text Books:

1. Craig, J.J., "Introduction to Robotics: Mechanics and Control," Pearson
2. Mikell P. Groover, "Industrial Robotics: Technology, Programming, and Applications"
3. Siciliano, Bruno and Khatib, Oussama, "Springer Handbook of Robotics"

References:

1. Fu, Gonzalez, and Lee, "Robotics: Control, Sensing, Vision, and Intelligence"
2. Richard D. Klafter, Thomas A. Chmielewski, "Robotic Engineering"
3. RIA/ISO Standards for Industrial Robotics Safety

Online Resources:

Website Name
1. https://www.ros.org 2. https://robodk.com 3. https://www.universal-robots.com 4. https://www.mathworks.com/solutions/robotics.html 5. https://www.sciencedirect.com/journal/robotics-and-computer-integrated-manufacturing 6. https://towardsdatascience.com/tagged/robotics

List of Experiments.

1. Robot arm programming for pick-and-place tasks
2. Inverse kinematics implementation using Python/ROS
3. Path planning and trajectory generation
4. Vision system integration for part recognition
5. Force sensor-based adaptive control

6. AI-based object classification using a robotic arm
7. Simulation of a robotic cell for assembly operations
8. Safety interlock implementation for industrial robots

List of Assignments:

1. Robot workspace analysis and DH parameter modeling
2. Offline programming using RoboDK or similar simulator
3. Vision dataset creation and labeling for robotic vision tasks
4. Case study on robotic automation in a selected industry
5. Motion profile design for speed and accuracy optimization
6. Final project: Report and implementation of a robotic solution

Assessment :

Term Work: Term Work shall consist of at least 8 practicals' based on the above list. Also, Term work Journal must include at least 2 assignments.

Term Work Marks: 25 Marks (Total marks) = 15 Marks (Experiment) + 5 Marks (Assignments) + 5 Marks (Attendance)

Practical& Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result
9.00 - 10.00	90.0 - 100	O (Outstanding)
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)
5.00 - < 5.50	50.0 - < 55.0	C (Average)
4.00 - < 5.00	40.0 - < 50.0	P (Pass)
Below 4.00	Below 40.0	F (Fail)
Ab (Absent)	-	Absent

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Offg. Associate Dean
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Dr. Shivram Garge Offg. Dean
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Appendix B

Justification for
M.Tech. (Robotics and Process Automation)

1.	Necessity for starting the course:	**The demand for M.Tech. (Robotics and Process Automation). The rapid evolution of Industry 4.0 technologies has created a pressing demand for highly skilled professionals in robotics and automation. Across manufacturing, healthcare, logistics, agriculture, and service sectors, robotics and intelligent automation are revolutionizing traditional processes. There is an urgent need for a specialized postgraduate program that can prepare graduates to meet these dynamic technological and industrial challenges.**
2.	Whether the UGC has recommended the course:	**Yes**
3.	Whether all the courses have commenced from the academic year 2023-24	**Yes, the Program started from A.Y 2025-26 as per NEP 2020 Policy.**
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	**Self-financed Yes. Some experts are called as adjunct or visiting faculties.**
5.	To give details regarding the duration of the Course and is it possible to compress the course?:	**2 years. Not possible to compress the program.**
6.	The intake capacity of each course and no. of admissions given in the current academic year:	**10 seats for one division. Admissions will be held from 2025-2026 onwards.**
7.	Opportunities of Employability / Employment available after undertaking these courses:	**M.Tech. in (Robotics and Process Automation) can open up various opportunities and employment prospects across various private industries and government sectors. With various roles as a System Engineer, Automation Engineer, Robotics Engineer, System Analyst, Data Analyst, and many more.**

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