Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science andCommerce, Baramati

(Autonomous)

Academic Year 2023-2024

NEP Pattern

Course Structure for M.Sc. - II: Electronic Science

Semester	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
III	Major (Mandatory)	ELE-601-MJM	Advanced Communication System	Theory	04
	Major (Mandatory)	ELE-602-MJM	Emerging Trends in Embedded Systems	Theory	04
	Major (Mandatory)	ELE-603-MJM	Practical Course –V	Practical	02
	Major (Mandatory)	ELE-604-MJM	Practical Course –VI	Practical	02
	Major (Elective)	ELE-611-MJE(A)	Fundamentals of Programmable Logic Controller (PLC) and Programming	Theory	02
		ELE-611-MJE(B)	IoT and Raspberry Pi Programming		
	Major (Elective)	ELE-612-MJE(A)	Programmable Logic Controller (PLC) -Lab	Practical	02
		ELE-612-MJE(B)	IoT and Raspberry pi-Lab		
	Research Project(RP)	ELE-621-RP	Project	Practical	04
	Total Credits Semester III				**20**
V	Major (Mandatory)	ELE-651-MJM	Control System	Theory	04
	Major (Mandatory)	ELE-652-MJM	Fundamentals of Artificial Intelligence and ML	Theory	04
	Major (Mandatory)	ELE-653-MJM	Practical Course -VII	Practical	02
	Major (Elective)	ELE-661-MJE(A)	Wireless Sensor Network	Theory	02
		ELE-661-MJE(B)	Advanced Power Electronics		
	Major (Elective)	ELE-662-MJE(A)	Wireless Sensor Network -Lab	Practical	02
		ELE-662-MJE(B)	Power Electronics - Lab		
	Research Project(RP)	ELE-681-RP	Project+ Research Paper Publication	Practical	06
	Total Credits Semester III				**20**

ELE-601-MJM: Advanced Communication System (4 Credits)

Objectives:

1. To learn analog and digital modulation techniques
2. Study the noise and source.
3. To study basic digital communication system and digital codes.
4. To learn error detection and correction codes.
5. To study various digital data communication systems
6. To understand the advanced communication system.
7. To study Satellite applications.

Course Outcome:

CO1. Student will be able to learn analog and digital modulation techniques.
CO2. Develop ability to Detection and Error Correction.
CO3. To know the working principle of advanced digital communication systems
CO4. Student will be able to learn advanced communication technologies.
CO5. Student will be able to explain the satellite signal processing.
CO6. They will be able to understand various aspects of satellite channel and satellite transponder
CO7. They will be able to understand various multiple access formats used in communications

Unit 1: Analog Communication **[10]**

Analog communication systems, Modulation, Bandwidth requirements, External and Internal noise,Theory of Amplitude modulation, Theory of frequency and Phase modulation, sidebands and modulation index, Noise and Frequency modulation, Analog base band Transmission.

Unit 1: Digital Communication **[15]**

Digital Communication Pulse modulation, Pulse amplitude modulation, pulse width modulation, pulse position modulation, Delta modulation, Adaptive delta modulation, Digital modulation techniques- ASK, FSK, PSK, QAM, M-ary digital modulation techniques. Digital base band transmission. Coding Techniques- Introduction to the Coding, Alpha - Numeric coding, Parity Check Coding, Hamming Code, Concept of Systematic Code, RZ, NRZ, Manchester code, AMI, Error Detection and Error Correction.

Unit 2: Advanced Communication Systems **[20]**

Satellite Communication, Transponder model, the satellite front end, RF filtering of digital carriers, Satellite signal processing, Transponder Limiting, Non linear satellite amplifiers, Effect of non linear amplification on digital carriers Satellite for Television applications: Direct-To-Home (DTH) and Cable TV. Voice and Data communication, Earth observation (Remote Sensing) applications, Military applications. Principle of digital telephony. Cellular Phones concept, Frequency reuse, Capacity expansion techniques- Cell splitting and cell sectoring, working of a typical cellular system. Telephone.

Unit 2: Communication Technologies **[15]**

FDMA - FDMA system, Nonlinear amplification with multiple FDMA Carriers, FDMA, FDMA Nonlinear analysis, FDMA channelization, AM/PM conversion with FDMA.
TDMA -The TDMA system, preamble design, Satellite Effects on TDMA performance, Network synchronization, SS TDMA
CDMA - Direct Sequence CDMA system, Performance of DS CDMA, satellite systems, Frequency Hopped CDMA
Integrated Services Digital Network (ISDN), OFDM, IrDA, PSTN, digital exchanges, VSAT, GSM.

Text / Reference Books

1. Electronic Communication Systems, George Kennedy and Bernard Davis Publ. Tata McGraw Hill.
2. Electronic communications, Dennis Roddy and John Coolen, Pearson Publ.
3. Communication Electronics Principles and applications, Louis E. Frenzel, Tata McGrawHill.
4. Digital data communication, Miller Tomasi, Advanced Electronic Communication Systems,6/e, Pearson, 2015.
5. W.C.Y.Lee, Mobile Cellular Telecommunication, McGraw Hill, 2010.
6. Timothy Pratt, Charles W. Bostian, Jeremy E. Allnutt, Satellite Communications, Singapore : John Wiley and Sons Inc. 2003 3. Dennis Roddy, Satellite Communications. New York : McGraw-Hill, 2001

Course Outcome	Program Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	-	-	-	-	-	-	-	-
CO2	2	3	2	2	2	-	2	-	-	-
CO3	2	2	-	2	2	2	-	-	-	-
CO4	2	3	1	1	1	-	-	-	-	-
CO5	3	1	-	-	-	1	-	2	2	2
CO6	2	2	2	1	2	-	2	2	1	-
CO7	3	3	-	3	1	2	-	-	-	-

Justification of Mapping

PO1: Comprehensive Knowledge and Understanding:

The course outcomes (COs) contribute to the development of students' Comprehensive knowledge in communication engineering. For example, CO1, CO3, CO4 require students to analog, digital modulation fundamental and advanced communication concept in communication engineering. CO2 require students to apply these concepts to error detection methodologies in communicated signal and learn advance communication technology. CO5, CO6 and CO7 required for Satellite and advanced communication key concepts.

PO2: **Practical, Professional, and Procedural Knowledge:**

The entire COs contributes to the development of students' Practical, Professional, and Procedural Knowledge. CO1, CO3, CO4 require for Knowledge of analog, digital and advanced communication technologies and practical implementation. CO2 contribute practical Knowledge of error correction and detection methods. CO5, CO6 and CO7 required Professional and Procedural Knowledge of Satellite and format structure real word applications.

PO3: Entrepreneurial Mindset, Innovation, and Business Understanding:

The CO2, CO4, and CO6 contribute to advanced digital communication technologies; help to develop project idea, implementation for various applications such as agriculture, home automation. Which enhance the understand business principles, market dynamics strategies.

PO4: Specialized Skills Critical Thinking and Problem Solving

The entire COs contributes to the development of students' critical thinking and problem-solving skills. For example, CO2, CO3, CO4 require students to think critically about digital communication techniques, error correction and detection methods and advanced communication concept. CO5, -CO7 require students to use their knowledge for Satellite communication technology.

PO5: Research, Analytical Reasoning, and Ethical Conduct:

The entire COs contributes to the development of students' research-related skills and scientific temper. CO3, CO4 CO6 and CO7 require students to Understanding scientific approach and research skills in exploring the principles of advanced digital communication technology as well as advance satellite communication technology, frame format.

PO6: Communication, Collaboration, and Leadership:

The CO3,5,7 contribute to the development knowledge of advanced digital communication techniques use for collaboratively in diverse applications.

PO7: Digital Proficiency and Technological Skills:

CO2, 6 contributes to error correction and detection skill as well as advanced satellite communication applications.

PO8: Multicultural Competence, Inclusive Spirit, and Empathy:

The CO6, and CO7 required for use of satellite communication technology for diverse applications.

PO9: Value Inculcation, Environmental Awareness, and Ethical Practices:

CO5, CO6: required for understanding the environmental impact of communication systems is crucial for promoting sustainability in the field.

PO10: Autonomy, Responsibility, and Accountability:

Learning advanced communication technology enhances personal and professional competence in keeping up with technological advancements in the field, contributing to social competence in conveying technical information to diverse audiences.

ELE-602-MJM: Emerging Trends in Embedded Systems (Credit-4)

Objectives:

1. To study 32-bit Processor and Controller.
2. To learn ARM Cortex-M3.
3. To get familiar with operating system
4. To get acquainted to fundamentals of operating system
5. To Understand basic programming of RTOS
6. To introduce Multiprocessor
7. To understand case study of RTOS

Course Outcomes:

1 Design embedded applications with operating system support.
2. Design 32-bit system.
3. Interfacing of ARM to Various Sensor
4. Concept of Operating System
5. Basic programming of RTOS
6. Concept of multiprocessor
7. Case Study of RTOS

Unit 1: ARM Cortex-M3 Processor Architecture [17]

Introduction: What Is the ARM Cortex-M3 Processor, Background of ARM and ARM Architecture,Cortex-M3 Processor Applications, Registers, Operation Modes, Memory Maps, The Pipeline, Bus Interfaces on the Cortex-M3, Other Interfaces on the Cortex-M3, Exceptions, Built-In Nested Vectored Interrupt Controller, Interrupt Behavior, Cortex-M3 Programming, Exception Programming, Advanced Programming Features and System Behavior, The Memory Protection Unit, Other Cortex-M3 Features, Debug Architecture, Debugging Components, Choosing a Cortex-M3 Product, Development Tools, Development Using the GNU Tool Chain.

Unit-2 : ARM Cortex-M3 Processor Implementation [15]

LPC176XIntroduction, Features, Applications, Device, information, Architectural overview, ARM Cortex-M3 processor, Block diagram, Memory maps, Clocking and Power control functions, Nested Vectored Interrupt Controller, Pin configuration, Pin connect block, GPIO, Ethernet, UART, CAN, SPI, I2C, Timer, Repetitive Interrupt Timer, System Tick Timer, PWM,Motor control PWM, ADC, DAC, RTC, WDT.
Programming: GPIO, UART, Timer, PWM, ADC, DAC, RTC.

Unit-3 : Introduction to Operating Systems [13]

Brief history of OS, Operating system basics and types of operating systems The BIOS and Boot Process: BIOS Actions, Operating System, Boot Process System calls, files, processes, design and implementation of processes, communication between processes Memory Management: segmentation and paging Memories: virtual, cache etc.

Unit-4: Real Time Operating Systems (RTOS) [15]

Operating System basics, Types of Operating Systems, Tasks, Process, Threads, Multiprocessing and Multi tasking, Task Scheduling, Threads-Processes-Scheduling putting them together, Task Communication, Task Synchronization, Device Drivers, How to choose an RTOS.

CASE STUDIES OF RTOS: RT Linux, Micro C/OS-II, Vx works, embedded linux, tiny OS and basic concepts of android OS.

Text / Reference Books:

1. The Definitive Guide to the ARM CORTEX-M3 2nd edition, by Joseph Yiu.
2. Using the Free RTOS Real Time Kernel ARM Cortex-M3 Edition, by Richard Barry
3. UM10360 LPC176x/5x User manual.
4. Operating Systems Concept, Galvin, John Willey and Sons
5. Operating System Concepts and Techniques,M. Naghibzadeh.

Course Outcome		Program Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	3	1	1	2	3	2	2	1
CO2	-	-	3	2	-	3	-	3	-	2
CO3	3	-	-	-	-	-	-	-		-
CO4	-	-	-	-	-	-	-	1	3	1
CO5	1	2	2	-	3	-	2	-	-	-
CO6	-	1	-	-	-	2	-	1	-	-
CO7	2	1	-	-	-	-	-	-	-	-

Justification of Mapping

PO1: Comprehensive Knowledge and Understanding:

CO1: This CO focuses on practical application design involving ARM architecture and operating system integration.

CO3: Knowledge of various development tools used in ARM-based development environments is crucial for students to effectively design and implement embedded applications.

CO5:Basic programming skills specific to RTOS lay the foundation for more advanced concepts and techniques, which are imperative for achieving comprehensive knowledge and understanding in embedded systems.

CO7: This CO introduces students to practical aspects of case study of RTOS a critical skill for developing embedded applications.

PO2: Practical, Professional, and Procedural Knowledge:

CO1: This course outcome directly addresses the practical aspect of designing embedded applications with operating system support, which is essential for professionals in the field.

CO5: Practical knowledge in basic programming of RTOS is essential for professionals to implement functionalities in embedded systems.

CO6: Understanding advanced multiprocessor complex functionalities efficiently in embedded applications.

CO7: This outcome provides practical knowledge of RTOS.

PO3: Entrepreneurial Mindset, Innovation, and Business Understanding

CO1: This outcome fosters an entrepreneurial mindset by providing students with the skills to create innovative embedded applications that can cater to various market demands.

CO2: Understanding the architecture of ARM processors allows students to innovate and develop novel solutions tailored to specific business needs.

CO5: Proficiency in basic RTOS programming enables students to innovate by implementing unique features and functionalities in their embedded applications.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:

CO1: This outcome demands specialized skills in designing embedded applications, requiring critical thinking and problem-solving abilities to address the challenges associated with operating system integration in embedded systems.

CO2: Understanding the architecture of ARM processors necessitates critical thinking to comprehend the complexities of hardware design and problem-solving skills to optimize system performance and resource utilization.

PO5: Research, Analytical Reasoning, and Ethical Conduct:

CO1: This outcome involves research into existing embedded systems designs and analytical reasoning to determine the most suitable approaches for integrating operating system support while adhering to ethical standards in the design process.

CO5: Researching RTOS programming techniques and analytical reasoning to optimize code performance are essential aspects of basic RTOS programming, along with ethical conduct in respecting software licenses and intellectual property rights.

PO6: Communication, Collaboration, and Leadership:

CO1: Communication skills are essential for effectively conveying design requirements and collaborating with team members to integrate operating system support into embedded applications.

CO2: Understanding ARM architecture involves effective communication of technical concepts to team members and collaborating with them to design efficient embedded systems.

CO6: Collaboration may occur through joint exploration of advanced Multiprocessor concepts and brainstorming sessions to solve complex programming problems.

PO7: Digital Proficiency and Technological Skills:

CO1: This outcome directly contributes to digital proficiency by providing students with the skills needed to design embedded applications that utilize operating system support efficiently.

CO5: Proficiency in basic RTOS programming enhances digital skills by enabling students to write efficient code for RTOS-based embedded systems, thereby leveraging the capabilities of these processors.

PO8: Multicultural Competence, Inclusive Spirit, and Empathy:

CO1: Understanding diverse cultural perspectives and fostering an inclusive spirit is essential when working in multicultural teams or developing products for global markets

CO2: Studying the architecture of ARM processors may involve exploring how technology impacts different cultures and societies. Promoting an inclusive spirit involves recognizing the contributions of diverse communities to technological advancements.

CO4: Concept of Operating System considering the cultural implications of technology adoption and ensuring that embedded applications are accessible and inclusive to users from diverse backgrounds.

CO6: Advanced multiprocessor concepts may involve exploring how technology can be leveraged to address societal challenges and promote inclusivity, demonstrating a commitment to multicultural competence

PO9: Value Inculcation, Environmental Awareness, and Ethical Practices:

CO1: Inculcating values such as integrity and responsibility is crucial when designing embedded applications, ensuring that they meet ethical standards and serve societal needs effectively.

CO4: Concept of Operating System with an emphasis on energy efficiency and sustainability contributes to environmental awareness and ethical practices. Value inculcation involves instilling a sense of responsibility towards minimizing the environmental footprint of embedded systems.

PO10: Autonomy, Responsibility, and Accountability:

CO1: Autonomy is fostered as students are given the responsibility to design embedded applications independently, demonstrating accountability for their design decisions and project outcomes.

CO2: Understanding ARM architecture allows students to autonomously explore and analyze various architectural features, taking responsibility for selecting appropriate architectures for their embedded applications and being accountable for the performance and efficiency of their designs.

CO4: Concept of Operating System requires students to autonomously make design decisions, take responsibility for meeting system requirements, and be accountable for the performance and reliability of their designs.

ELE-603-MJM: Practical course V (2- Credits)

Objectives:

1. To learn difference between analog modulation techniques.
2. To learn difference between digital modulation techniques.
3. To learn different control system.
4. To make students aware of various actuators
5. To learn various power Electronics Circuit.
6. To study different types of Motor.
7. To know the Multiplexing.

Course Outcomes: On completion of the course, students will be able to

CO1. Design different analog and digital Modulation Techniques.
CO2. Design Various control system Application.
CO3. Design Various Power Electronic Circuit.
CO4. Study different motor controlling techniques.
CO5. Student will able to design demodulation system
CO6. Student will able to design ON-OFF Controller, P, PI and PID system
CO7. Understand the operation of various power supplies.

Laboratory Practical: Any 15 Practical from following

1. Delta modulation
2. AM modulation/demodulation
3. Design PCM encoder/ decoder system
4. Design of FSK transmitter and receiver
5. Time division Multiplexing
6. Telemetry Applications
7. Design of FSK transmitter and receiver
8. Design of Binary Phase Shift Keying
9. Signal conditioning circuits for analog controller
10. Design and implement ON-OFF Controller
11. Design and implement P / PI / PID controller
12. Design water level control system
13. To study the position / velocity control of dc servo motor
14. Flow control using solenoid valve
15. Study of optical position encoder
16. Study of DC servo motor/BLDC motor.
17. Study of PMDC motor toque speed characteristics
18. Study of AC servo motor, its speed control/position control
19. Set up a flow control system using suitable flow sensor and actuator
20. Study of actuators and their driving circuit (solenoids, motors etc.)
21. Study of digital sensor

Activity: Industrial Visit / Hobby project (equivalent to two practical experiments)

Course Outcome		Program Outcomes								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	-	-	2	-	-	-	-	-	-
CO2	-	3	2	3	2	2	2	-	2	2
CO3	2	1	2	-	2	-	-	1	-	-
CO4	3	3	2	3	1	2	-	-	2	2
CO5	2	-	-	-	-	-	-	-	-	-
CO6	-	2	2	2	2	3	3	-	2	3
CO7	2	3	3	3	-	3	-	2	-	2

Justification of Mapping

PO1: Comprehensive Knowledge and Understanding:

The course outcomes (COs) contribute to the development of students' Comprehensive knowledge in electrical and electronics engineering. For example, CO1, CO5 require to know the modulation and demodulation techniques and design the necessary circuit. CO3, CO4 and CO6 required getting knowledge of controlling techniques. CO7 require students to understand concepts of power supply.

PO2: **Practical, Professional, and Procedural Knowledge:**

The entire COs contributes to the development of students' Practical, Professional, and Procedural Knowledge. CO2, CO3, CO4 require for Knowledge of digital and analog system design for various application. CO6 contribute practical Knowledge of various controlling methods. CO7 required various power supply design as per requirement. .

PO3: Entrepreneurial Mindset, Innovation, and Business Understanding:

The CO2, CO3, CO4, CO6 and CO7 contribute to analog and digital system design for diverse field. It helps to develop project idea, implementation for various applications such as agriculture, home automation. Which enhance the understand business principles, market dynamics strategies.

PO4: Specialized Skills Critical Thinking and Problem Solving

The entire COs contributes to the development of students' critical thinking and problem-solving skills. For example, CO1 require students to think critically about operation of analog and digital modulation circuit. CO2, CO4 and CO6 require students to think critically about how to design analog or digital circuit for controlling dedicated application and its response. CO7 require students to think critically about the power supply design.

.**PO5: Research, Analytical Reasoning, and Ethical Conduct:**

The entire COs contributes to the development of students' research-related skills and scientific temper. CO2, CO3, CO4 and CO6 require for students to think to design circuit for problem solving and formulate the hypothesis.

PO6: Communication, Collaboration, and Leadership:

The CO2,4,6,7 contribute to the development knowledge of electronic system for collaboratively in diverse applications.

PO7: Digital Proficiency and Technological Skills:

CO2, 6 contributes to develop analog and digital system design.

PO8: Multicultural Competence, Inclusive Spirit, and Empathy:

The CO required for use of electronic system design.

PO9: Value Inculcation, Environmental Awareness, and Ethical Practices:

CO2, CO4, CO6: required to student for thinking development of analog or digital circuit for simplified practical problems for soil, water or environment parameter monitoring and easy handling laboratory instruments.

PO10: Autonomy, Responsibility, and Accountability:

Students to develop their ability to work independently or as a team to solve real-world problems. Students develop their skills for starting own start-up in electronics design. Students use their knowledge to develop suitable solution for interdisciplinary field such as physics, chemistry, agriculture, industrial, botany etc.

ELE-604-MJM : Practical course VI (2 Credits)

Objectives:

1. To learn ARM Cortex-M3.
2. To learn Architecture of ARM
3. To make the students aware of ARM Cortex Programming.
4. To make the students aware of Basic of RTOS
5. To Make student aware about RTOS Programming.
6. To Learn MATLAB Programming
7. To study MATLAB Programming for Communication.

Course Outcomes: On completion of the course, students will be able to

1. Design embedded applications with operating system support
2. Develop Basic Programming of ARM
3. Develop various code for ARM Controller
4. Design of Basic RTOS Programming
5. Basics of Matlab Programming
6. Matlab programming for Communication
7. Use of various Simulation software.

Laboratory Practical: Any 15 Practical from.

1. Simple ARM C Program for arithmetic and logical operations
2. Interfacing of LED to 32-bit microcontroller.
3. Interfacing Alphanumeric LCD to 32-bit microcontroller.
4. Interfacing matrix keyboard to 32-bit microcontroller.
5. Programming ADC of 32-bit microcontroller.
6. Programming DAC of 32-bit microcontroller.
7. Programming UART of 32-bit microcontroller.
8. Interfacing of GSM to 32-bit microcontroller.
9. Interfacing of RTC to 32-bit microcontroller.
10. Interfacing of Stepper motor to 32-bit microcontroller.
11. Interfacing of GPS to 32-bit microcontroller.
12. ARM C Program for Two digit frequency counter or event counter using timer.
13. ARM C Program for DC motor control using PWM /intensity control of LED.
14. ARM C Program for Touch screen interfacing.
15. ARM C Program for Real Time Clock display on LCD/ HyperTerminal(I2C).
16. Implementation of Multitasking using RTOS.
17. Implementation of Semaphore using RTOS
18. Interfacing of relay.
19. Interfacing of seven segment display.
20. Interfacing of digital Sensor.

Experiments using MATLAB

1. Phase shift keying (PSK)
2. Generation and reception of BPSK
3. Generation and reception of FSK
4. Generation and reception of QPSK

Activity: Industrial Visit / Hobby project (equivalent to 2 practical experiments)

Course Outcome	Program Outcome									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	-	-	-	-	-	3	-	-	3
CO2	-	-	1	-	-	2	--	-	-	-
CO3	-	2	-	-	-	-	-	-	-	-
CO4	-	-	-	2	-	-	-	-	-	3
CO5	-	3	-	-	-	-	-	3	-	-
CO6	1	-	-	-	-	3	-	-	-	-
CO7	-	-	-	-	1	-	-	-	-	-

Justification of Mapping

PO1: Comprehensive Knowledge and Understanding:

CO1: Mastering this competency ensures students comprehend the intricacies of hardware-software interactions, real-time constraints, and resource management, thereby fostering comprehensive knowledge in the field of embedded systems.

CO6: By delving into Matlab programming for communication, students gain comprehensive knowledge of signal processing, system modeling, and various communication techniques. This competency broadens their understanding of communication principles, which is essential for designing efficient embedded systems with robust communication capabilities.

PO2:**Practical, Professional, and Procedural Knowledge:**

CO3: By developing various code for ARM controllers, students gain hands-on experience and procedural knowledge in writing efficient and functional code for embedded systems. This practical expertise prepares them for professional roles where they need to work with ARM-based microcontrollers or processors, enhancing their practical, professional, and procedural knowledge.

CO5: Learning the basics of Matlab programming enables students to apply mathematical and computational techniques to solve engineering problems, analyze data, and develop algorithms.

PO3:Entrepreneurial Mindset, Innovation, and Business Understanding:

CO2: By mastering basic ARM programming, students can explore novel applications, design innovative products, and contribute to business understanding by leveraging ARM technology to create competitive advantages in the market.

PO4:Specialized Skills, Critical Thinking, and Problem-Solving:

CO4: Mastering the design of basic RTOS programming requires students to apply critical thinking to understand the intricacies of task scheduling, synchronization mechanisms, and resource management in real-time embedded systems.

PO5:Research, Analytical Reasoning, and Ethical Conduct:

CO7: Through the use of simulation tools, students engage in research-oriented activities, such as modeling, experimentation, and analysis, to explore complex systems and phenomena. They apply analytical reasoning to interpret simulation results, draw conclusions, and make informed decisions

PO6: Communication, Collaboration, and Leadership:

CO2: Through the process of learning and mastering ARM programming, students are encouraged to communicate effectively about their ideas, challenges, and solutions. Collaboration is essential in group projects or discussions where students may work together to troubleshoot code, exchange knowledge, and collectively solve problems

CO6: Through Matlab programming, students learn to communicate effectively by articulating their ideas, methodologies, and findings in written reports, presentations, and discussions. Collaboration is facilitated as students may work together on Matlab projects, share code, and collaborate on research or analysis tasks related to communication systems

PO7: Digital Proficiency and Technological Skills:

CO1: Through the design of embedded applications with operating system support, students develop proficiency in utilizing digital technologies, including embedded systems, microcontrollers, and operating systems. They gain hands-on experience in integrating hardware and software components to create functional embedded systems, thereby enhancing their digital proficiency

PO8:Multicultural Competence, Inclusive Spirit, and Empathy:

CO5: As students learn the basics of Matlab programming, they engage in diverse perspectives and experiences, creating an inclusive environment where everyone's contributions are valued. By working together on Matlab projects, students develop empathy as they understand and appreciate the different backgrounds, cultures, and perspectives of their peers

PO9: Value Inculcation, Environmental Awareness, and Ethical Practices:

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PO10:Autonomy, Responsibility, and Accountability:

CO1: As students design embedded applications with operating system support, they are given autonomy to make decisions regarding system architecture, resource allocation, and software design. They take responsibility for their design choices, ensuring that the embedded application meets specified requirements and functions reliably.

CO4: Students autonomously design and implement basic RTOS programming solutions, taking responsibility for ensuring timely task execution, efficient resource utilization, and system reliability. They are held accountable for the performance of their RTOS-based applications, learning to troubleshoot issues, optimize code, and deliver high-quality solutions

ELE-611-MJE(A): - Fundamentals of Programmable Logic Controller (PLC) and Programming (Credits : 2)

Objectives:

1. To make awareness of programmable logic controller hardware.
2. To know working of timers and counters in PLC.
3. To familiarize programming in PLC.
4. To learn different modes of PLC programming.
5. To study some case studies using PLC.
6. To develop applications of PLC.
7. To learn concept of sinking and sourcing

Course Outcomes:

CO1. Identify the main parts of a programmable logic controller.

CO2. Describe how a programmable logic controller is programmed.

CO3. Develop logic gate circuits from Boolean expressions and convert it to programming.

CO4. Write a Ladder Logic Program.

CO5. Describe switching elements on input/output modules.

CO6. Describe functions of programmable logic controller components.

CO7. Test a programmable logic controller Discrete Output device for correct response.

Unit 1: Introduction to PLC [12]

Need and benefits of Automation, Tools of Automation – PLC, PLC Architecture Block diagram, Working, CPU – Function, scanning cycle, Speed of execution, Memory Organization and function, sink and source concept in PLC, Input/output module with reference to sink or source, output module relay, transistor, triac, Signal conditioning, PLC Characteristics, PLC types – Fixed and Modular, PLC applications, PC v/s PLC.

Unit 2: PLC Programming [08]

Programming methods- Logic control elements (NOT, AND, OR, NAND, NOR etc.) ladder diagrams, function blocks, statement list, programming a PLC, programming terminals, ladder relay instructions, ladder relay programming (digital gates, Boolean expression, mux-demux, flip flop)

Unit 3: Timers, Counters and Registers [10]

Types of timers, programming timers, off-delay timers, pulse timers, programming examples, forms of counter, programming, up and down counting, timers with counters, sequencer, data handling: registers and bits, data handling, arithmetic functions, closed loop control shift registers, ladder programs, Concept of smart PLC,HMI using smart PLC.

Text /Reference Books:

1. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers Principles and Applications", Fifth Edition, Prentice Hall Publication, New Delhi, 2002.
2. L.A. Bryan, E.A. Bryan, "Programmable controller theory and Implementations"

secondedition, An Industrial Text Company Publication.
3. W. Bolton, "Programmable Logic Controllers", Fifth Edition, Elsevier Publication
4. Dunning G., "Introduction to Programmable Logic Controllers", Thomson/ Delmar learning,2005, ISBN – 13: 9781401884260.
5. John R. Hackworth and Frederick D. Hackworth Jr, "Programmable Logic Controllers: Programming methods and Applications", First Edition, Pearson Publication.

Course Outcomes	Program Outcome									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	2	2	2	3	-	2	3
CO2	-	-	2	-	-	-	-	-	-	-
CO3	-	2	-	-	3	-	-	2	-	-
CO4	-	-	2	-	-	-	-	2	-	-
CO5	-	-	-	3	-	-	-	-	2	-
CO6	-	-	-	-	-	2	-	-	-	3
CO7	3	2	-	-	-	-	3	-	-	-

Justification of Mapping

PO1: Comprehensive Knowledge and Understanding:

CO1: Directly addresses identifying main parts of a PLC, aligning with the need for comprehensive knowledge.

CO7: Testing PLC discrete output devices align with the need to ensure correct responses, demonstrating practical application of knowledge.

PO2: Practical, Professional, and Procedural Knowledge:

CO1: Identifying the main parts of a PLC is crucial for practical skills and expertise in handling PLC systems, aligning well with the practical, professional, and procedural knowledge expected.

CO3: Developing logic gate circuits and converting them to programming showcases practical skills and effective application in real-world scenarios.

CO7: Testing PLC discrete output devices for correct response highlights proficiency in practical skills and adherence to industry standards and regulations.

PO3:. Entrepreneurial Mindset, Innovation, and Business Understanding:

CO1: While identifying the main parts of a PLC is foundational, it does not directly align with cultivating an entrepreneurial mindset or understanding business principles.

CO2: - Describing how a PLC is programmed is important for technical understanding but may not directly contribute to fostering innovation or understanding business principles.

CO4: Writing ladder logic programs is essential for technical proficiency but may not directly contributes to entrepreneurial mindset or business understanding.

PO4: Specialized Skills, Critical Thinking, and Problem-Solving:

CO1: Identifying the main parts of a PLC is a foundational technical skill but may not directly demonstrate critical thinking or problem-solving abilities.

CO5: Describing switching elements on I/O modules is primarily a technical skill and may not directly demonstrate critical thinking or problem-solving abilities.

PO5: Research, Analytical Reasoning, and Ethical Conduct:

CO1: While identifying the main parts of a PLC requires some observational skills, it may not directly demonstrate analytical reasoning or ethical conduct.

CO3: Developing logic gate circuits and converting them to programming involves analytical reasoning and adherence to logical principles, aligning well with research and ethical conduct.

PO6: Communication, Collaboration, and Leadership:

CO1: While identifying the main parts of a PLC is important for communication, it may not directly demonstrate collaboration or leadership qualities.

CO6: Describing functions of PLC components requires technical knowledge but may not directly demonstrate communication, collaboration, or leadership.

PO7: Digital Proficiency and Technological Skills:

CO1: Identifying the main parts of a PLC requires proficiency in accessing information sources and understanding ICT-related terminology.

CO7: Testing a PLC discrete output device for correct response demands proficiency in using appropriate software and adapting to technological advancements.

PO8: Multicultural Competence, Inclusive Spirit, and Empathy:

CO3: Developing logic gate circuits and converting them to programming primarily involves technical proficiency and may not directly demonstrate multicultural competence or inclusive spirit.

CO4: Writing a ladder logic program is a technical task and may not directly relate to multicultural competence or inclusive spirit.

PO9: Value Inculcation, Environmental Awareness, and Ethical Practices:

CO1: While identifying the main parts of a PLC may not directly relate to environmental awareness or ethical practices, understanding the components can indirectly contribute to responsible citizenship by fostering knowledge of sustainable technologies.

CO5: Describing switching elements on I/O modules is primarily a technical skill and may not directly demonstrate environmental awareness or ethical practices.

PO10: Autonomy, Responsibility, and Accountability:

CO1: Identifying the main parts of a PLC demonstrates autonomy in knowledge application and contributes to effective project management within technical contexts.

CO6: Describing functions of PLC components requires autonomy in knowledge application and contributes to project management effectiveness within technical contexts.

ELE-611-MJE(B)- IoT and Raspberry Pi Programming (Credits : 2)

Course Objectives

1. Describe various loT enabled technologies.
2. Understand the concepts of M2M with necessary protocols.
3. Illustrate Python programming for loT
4. Examine the Python programming with Raspberry PI
5. Design web applications for loT

UNIT I- Introduction to Internet of Things and M2M: [12]

Definition and Characteristics of loT, Physical Design of IoT IoT Protocols, IoT communication models, IoT Communication APIs IoT enabled Technologies Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols, Embedded Systems, IoT Levels and Templates Domain Specific IoTs Home, City, Environment, Energy, Retail, Logistics, Agriculture, Industry, health and Lifestyle. Software defined networks, network function virtualization, difference between SDN and NFV for IoT Basics of IoT System Management with NETCOZF, YANG-NETCONF, YANG, SNMP NETOPPER.

UNIT II- Introduction to Python: [08]

Language features of Python, Data types, data structures, Control of flow, functions, modules, packaging file handling, data/time operations, classes, Exception handling Python packages ISON, XML, HTTPLib, URLLib, SMTPLib.

UNIT III- : Introduction to Raspberry PI [10]

Introduction to Raspberry PI, - Basic Python program with Raspberry PI , Programs with focus of interfacing external gadgets, controlling output, reading input from pins. Interfaces (serial, SPI, I2C) Programming.

Text Books:

1. Internet of Things - A Hands-on Approach, ArshdeepBahga and Vijay Madisetti, Universities Press, 2015,ISBN: 9788173719547.

Reference Books:

1. Designing the Internet of Things, Adrian McEwen, Hakim Cassimally, John Wiley and Sons, Ltd
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014,ISBN: 9789350239759
3. IOT (Internet of Things) Programming: A Simple and Fast Way of LearningIOT, kindle edition.

Course Outcome	Program Outcome									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	-	-	-	-	-	-	-	-
CO2	3	3	3	-	-	2	-	-	-	-
CO3	3	3	2	-	-	-	-	-	-	2
CO4	3	3	-	2	3	2	2	-	-	3
CO5	3	3	3	3	3	2	2	-	-	3
CO6	3	3	3	2	3	2	2	-	-	3
CO7	3	2	2	-	-	-	-	-	-	-

Justification of Mapping

PO1. Comprehensive Knowledge and Understanding:

CO1: Students acquiring a comprehensive understanding of the basic concepts, components, and architecture of the Internet of Things (IoT). This knowledge will enable them to design and develop IoT systems effectively.

CO2: Developing the ability to analyze and evaluate the performance, scalability, and availability of IoT systems and their applications. This requires a comprehensive understanding of the underlying principles and mechanisms.

CO3: Focuses on developing an understanding of Machine-to-Machine (M2M) communication and the necessary protocols associated with it. This knowledge is crucial for designing and implementing effective IoT systems.

CO4: Developing the ability to design Python programming solutions specifically for IoT applications. This requires a comprehensive understanding of Python language fundamentals and its application in the IoT context.

CO5: Developing the ability to implement Python programming solutions specifically using Raspberry Pi, a popular platform for IoT development. This requires a comprehensive understanding of Raspberry Pi hardware and Python programming for IoT.

CO6: Developing the ability to design web applications that interface with IoT systems. This requires a comprehensive understanding of web development principles, IoT protocols, and data integration techniques.

CO7: Focuses on developing an understanding of different Python packages that are commonly used in IoT development. This requires a comprehensive knowledge of various Python libraries and their functionalities in the context of IoT.

PO2. Practical, Professional, and Procedural Knowledge:

CO1: Which can be applied in real-world IoT projects and scenarios.

CO2: Analyze the performance, scalability, and availability of IoT systems and their applications, enabling them to make informed decisions and optimizations.

CO3: It can be applied in the design and implementation of M2M-based IoT systems.

CO4: Design Python programming solutions tailored for IoT applications, enabling students to develop efficient and effective IoT solutions.

CO5: Implement Python programming solutions using Raspberry Pi, allowing them to effectively utilize this platform for IoT development.

CO6: Design web applications that interface with IoT systems, enabling them to create user-friendly and interactive IoT applications.

CO7: Explain and utilize different Python packages commonly used in IoT development, making them familiar with industry-standard tools and frameworks.

PO3. Entrepreneurial Mindset, Innovation, and Business Understanding:

CO2: To analyze the performance, scalability, and availability of IoT systems and their applications, enabling them to identify business opportunities and ensure the successful deployment of IoT systems in real-world scenarios.

CO3: To understand M2M communication concepts and necessary protocols, which is essential for developing innovative and sustainable business models around M2M-based IoT solutions.

CO5: To utilize Raspberry Pi devices to implement Python programming solutions for IoT applications, enabling them to create efficient and cost-effective IoT systems.

CO6: To design web applications that interface with IoT systems, making them user-friendly and innovative, thus leading to greater market appeal and revenue-generating opportunities.

CO7: Students possessing entrepreneurial mindset and innovative thinking to understand and utilize different Python packages commonly used in IoT development, enabling them to develop cutting-edge IoT solutions and stay competitive in the growing IoT market.

PO4. Specialized Skills, Critical Thinking, and Problem-Solving:

CO4: Design Python solutions for IoT applications, allowing students to solve complex problems and develop efficient IoT systems.

CO5: Implement Python programming with Raspberry Pi, enabling them to solve problems related to hardware integration and data processing in IoT applications.

CO6: Apply specialized skills and critical thinking to design web applications for IoT, addressing user needs and solving problems related to user interface, data visualization, and remote control of IoT systems.

PO5. Research, Analytical Reasoning, and Ethical Conduct:

CO4: Designing Python programming solutions for IoT, ensuring the use of well-researched and efficient programming techniques in alignment with ethical standards.

CO5: Implementing Python programming with Raspberry Pi, ensuring the use of appropriate technologies and adhering to ethical principles during implementation.

CO6: Designing web applications for IoT, ensuring the use of well-researched design principles, data privacy considerations, and ethical practices.

PO6. Communication, Collaboration, and Leadership:

CO2: Analyzing the performance, scalability, and availability of IoT systems and their applications in a collaborative and effective manner.

CO4: Promoting effective leadership through effective communication and collaboration with team members.

CO5: Students to collaborate effectively with team members and communicate with stakeholders to implement Python programming with Raspberry Pi, promoting leadership through effective teamwork and communication skills.

CO6: Students to collaborate with peers and communicate with stakeholders to design web applications for IoT, promoting effective leadership through effective teamwork and communication skills.

PO7. Digital Proficiency and Technological Skills:

CO4: Students to demonstrate digital proficiency and technological skills by designing Python programming solutions for IoT, utilizing programming tools, libraries, and frameworks to develop efficient and effective IoT applications.

CO5: Students to apply digital proficiency and technological skills to implement Python programming with Raspberry Pi, utilizing hardware components, software development tools, and IoT frameworks to effectively integrate Python programs with Raspberry Pi.

CO6: Students to demonstrate digital proficiency and technological skills in designing web applications for IoT, utilizing web development tools, frameworks, and technologies to create user-friendly and scalable IoT web applications.

PO10. Autonomy, Responsibility, and Accountability:

CO3: Developing students' autonomy in comprehending M2M concepts and protocols, fostering responsibility in understanding communication technologies, and instilling accountability for applying these concepts effectively.

CO4: Empowering students to take autonomous steps in designing Python programs for IoT applications, promoting responsibility in creating efficient code and accountability for the functionality of their programs.

CO5: Encouraging students to autonomously implement Python programs on Raspberry Pi devices, instilling responsibility in executing code effectively on the platform and fostering accountability for the outcomes of their programming tasks.

CO6: Students to take responsibility for designing web applications for IoT systems, promoting autonomy in creating user-friendly interfaces and fostering accountability for the usability of their applications.

ELE-612-MJE(A)- Programmable Logic Controller (PLC) Lab (2 Credits)

Course Objectives

1. To learn Programmable Logic Controller techniques
2. To learn ladder programming.
3. To learn ladder programming for logical gate.
4. To make students aware of timer operation.
5. To learn simulator for PLC programming design
6. To study of sequential logic circuit.
7. To know the working of various application of PLC for controlling.

Course Outcomes: On completion of the course, students will be able to

CO1. Understand the ladder programming for PLC.
CO2. Design various logical gates using ladder.
CO3. Student will able to design sequential circuit using ladder logic
CO4. Student will able to know working of timer, counter using ladder programming.
CO5. Student will able to design circuits using simulator.
CO6. Student will able to design ladder programming for various applications.
CO7. Understand the design process of PID.

List of Experiments- Perform 15 Experiments.

1. Introduction to PLC and Ladder Logic Programming.
2. Implementation of PLC arithmetic instructions.
3. Write and implement a simple ladder logic program using digital inputs and outputs for PLC.
4. Study of Logic gates.
5. Study of latching and unlatching.
6. Write and implementation of simple ladder logic program using timer 1) On delay timer 2) Off delay timer 3) Retentive timer
7. Write and implementation of simple ladder logic program using counter. 1) UP counter 2) Down counter.
8. Programming PLC for sequential logic RS -FF,JK-FF,T-FF,D-FF
9. To study about conveyor control system using PLC
10. Write and implement ladder logic program to on-off the DC motor using PLC.
11. To study the traffic light controller system by using PLC.
12. Automatic indication of water level controller of a tank.
13. Implementation of PID controller.
14. Development of a logic diagram for Automatic door opening of the room.
15. Development of a logic diagram for temperature controller.
16. Programming PLC for Bottle filling plant.
17. Develop Ladder logic for heating process.
18. Develop ladder logic for a vending machine.
19. Development of a ladder diagram for Automatic street light controller.
20. Develop Ladder logic for star delta motor starter.

Activity: Industrial Visit / Hobby project (equivalent to 2 practical experiments)

Course Outcome	Program Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	3	-	2	-	2	1	-	1	3
CO2	3	3	-	1	-	-	2	-	-	-
CO3	2	1	-	2	-	-	3	-	-	-
CO4	3	3	-	3	-	-	2	-	-	2
CO5	2	2	-	2	-	2	3	-	2	1
CO6	3	3	3	-	2	3	3	-	3	1
CO7	2	3	-	3	3	-	2	-	-	2

Justification of Mapping

PO1: Comprehensive Knowledge and Understanding:

The course outcomes (COs) contribute to the development of students' Comprehensive knowledge in PLC programming. For example, CO1, CO5 require to know the ladder programming, use of simulator. CO2, CO3, CO4, CO6, CO7 required getting knowledge of ladder programming for various application design.

PO2: **Practical, Professional, and Procedural Knowledge:**

The entire COs contributes to the development of students' Practical, Professional, and Procedural Knowledge. All COs contribute to practical knowledge in ladder programming, circuit design, and PID design

PO3: Entrepreneurial Mindset, Innovation, and Business Understanding:

CO6 involves designing ladder programming for various applications, which may require innovative thinking and understanding of business requirements for automation.

PO4: Specialized Skills Critical Thinking and Problem Solving

The entire COs contributes to the development of students' critical thinking and problem-solving skills. For example, CO1, CO2, CO3, CO4, CO5, and CO7 involve critical thinking and problem-solving skills in understanding ladder programming, designing logical gates, sequential circuits, timers, counters, and PID controllers.

.**PO5: Research, Analytical Reasoning, and Ethical Conduct:**

The CO1, CO5 and CO6 contribute to the development of students' research-related skills and scientific temper. The direct research component may not be explicitly stated, students may need to conduct research to understand and apply ladder programming concepts effectively. Ethical conduct is implicitly incorporated into all activities, ensuring that students follow proper procedures and guidelines

PO6: Communication, Collaboration, and Leadership:

The CO6 contribute to the development knowledge of circuit design for controlling various applications. While not explicitly mentioned in the course outcomes, communication and collaboration may be involved when students work on design projects or simulations in groups. Leadership skills may be demonstrated by leading project teams or taking initiative in problem-solving

PO7: Digital Proficiency and Technological Skills:

CO1, CO2, CO3, CO4, CO5, CO6, and CO7 all contribute to digital proficiency and technological skills in PLC programming, circuit design and PID control.

PO8: Multicultural Competence, Inclusive Spirit, and Empathy:

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PO9: Value Inculcation, Environmental Awareness, and Ethical Practices:

Ethical practices are implicitly included in all COs, ensuring that students understand and adhere to ethical guidelines in PLC programming, circuit design, and PID control.

PO10: Autonomy, Responsibility, and Accountability:

Students develop autonomy, responsibility, and accountability through individual and group assignments, where they are required to apply their knowledge of ladder programming, circuit design, and PID control effectively.

ELE-612-MJE(B) – IoT and Raspberry Lab (2 Credits)

Objectives:

1. To understand Raspberry Pi basics.
2. To explore GPIO interfacing.
3. acquired knowledge and skills to develop practical projects.
4. To encourage student's creativity and innovation by exploring unique project ideas and experiment.
5. To understand IoT concepts, protocol and standards and familiarize with IoT hardware platform.
6. To learn how to interface various sensors and develop IoT applications and projects.
7. To explore integrating IoT devices with cloud platforms.

Course Outcomes: On completion of the course, students will be able to –

CO1: Understand Raspberry Pi Hardware.
CO2: Interface with external hardware components using the Raspberry.
CO3: Troubleshoot common issues encountered during Raspberry Pi development
CO4: Develop skills in interfacing various sensors with IoT devices,.
CO5: Design, develop, and deploy IoT applications
CO6: Design and develop scalable and maintainable IoT solutions.
CO7: Establish wireless connectivity for IoT devices using technologies like Wi-Fi, Bluetooth, cellular networks.

List of Experiments- Perform 15 Experiments.

Raspberry Pi Programming

1. LED array interfacing.
2. Interfacing Switch to control LED.
3. SSD Interfacing.
4. Interfacing of photocell sensor.
5. Temperature sensor Interfacing.
6. Interfacing of PIR sensor.
7. Camera Control using Raspberry Pi.

IoT Programming

1. To interface DHT11 sensor and write a program to print temperature and humidity readings.
2. To interface OLED and write a program to print temperature and humidity readings on it.
3. To interface Bluetooth and write a program to send sensor data to smartphone using Bluetooth
4. To interface Bluetooth and write a program to turn LED ON/OFF when _1'/'0' is received from smartphone using Bluetooth
5. Write a program to upload temperature and humidity data to thingspeak cloud
6. Home Automation
7. Smart irrigation
8. Air pollution monitoring
9. Smoke/Gas Detector
10. Smart parking

Activity: Industrial Visit / Hobby project (equivalent to 2 practical experiments)

Course Outcome	Program Outcome									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	-	-	-	-	-	-	-	-
CO2	3	3	-	-	-	-	-	-	-	3
CO3	3	3	2	2	3	-	2	-	-	3
CO4	3	3	2	2	3	2	2	-	-	3
CO5	3	3	2	2	3	-	2	-	-	2
CO6	3	3	2	2	3	2	2	-	-	3
CO7	3	2	2	2	3	2	3	-	-	3

Justification of Mapping

PO1. Comprehensive Knowledge and Understanding:

CO1: Enabling students to grasp the foundational aspects of IoT devices.

CO2: Equipping students with the skills to interact with external hardware, fostering a deeper understanding of IoT device connectivity and integration.

CO3: Enhancing students' ability to identify and resolve technical challenges, contributing to their overall proficiency in IoT device development.

CO4: Empowering students to work with diverse sensors, enhancing their knowledge base and practical skills in IoT sensor integration.

CO5: Enabling students to create and implement IoT applications, fostering a holistic understanding of IoT development processes.

CO6: Guiding students in creating sustainable and scalable IoT solutions, emphasizing the importance of efficient and maintainable IoT designs.

CO7: Educating students on wireless connectivity technologies, enhancing their knowledge of IoT communication protocols and networks.

PO2. Practical, Professional, and Procedural Knowledge:

CO1: Providing students with practical knowledge of the hardware components of Raspberry Pi, enabling them to apply this understanding in real-world scenarios.

CO2: Equips students with the professional skills to connect and interact with external hardware, enhancing their practical knowledge in integrating components with the Raspberry Pi.

CO3: Developing students' procedural knowledge in identifying and resolving technical challenges, enhancing their practical troubleshooting skills in Raspberry Pi development.

CO4: Providing students with practical expertise in integrating sensors with IoT devices, fostering their professional knowledge in sensor connectivity and data acquisition.

CO5: Enabling students to apply their practical, professional, and procedural knowledge in creating and deploying IoT applications, emphasizing hands-on experience in IoT development.

CO6: Guiding students in creating scalable and maintainable IoT solutions, enhancing their practical understanding of designing efficient and sustainable IoT projects.

CO7: Providing students with practical skills in setting up wireless connectivity for IoT devices, emphasizing their professional knowledge in utilizing various wireless technologies for IoT communication.

PO3. Entrepreneurial Mindset, Innovation, and Business Understanding:

CO3: Cultivating problem-solving skills and an entrepreneurial mindset in students, preparing them to address technical challenges effectively in IoT projects, which is essential for business success.

CO4: Encouraging students to innovate in sensor integration for IoT devices, fostering a business-oriented understanding of sensor technologies and their applications in entrepreneurial ventures.

CO5: Empowering students to innovate and create IoT applications, emphasizing the importance of business understanding in developing and deploying successful IoT projects.

CO6: Instilling in students the importance of scalability and maintainability in IoT solutions, fostering an entrepreneurial mindset focused on sustainable and business-oriented IoT development.

CO7: Emphasizing the entrepreneurial aspect of establishing wireless connectivity for IoT devices, encouraging students to innovate in connectivity solutions and understand the business implications of wireless technologies in IoT applications.

PO4. Specialized Skills, Critical Thinking, and Problem-Solving:

CO3: Developing students' critical thinking and problem-solving skills in identifying and resolving technical challenges during Raspberry Pi development, enhancing their specialized troubleshooting abilities.

CO4: Providing students with specialized skills in sensor integration for IoT devices, fostering critical thinking through analyzing sensor functionalities and problem-solving in sensor connectivity.

CO5: Empowering students with specialized skills in designing and deploying IoT applications, emphasizing critical thinking in creating innovative solutions and problem-solving in application development.

CO6: Guiding students in developing specialized skills to create scalable and maintainable IoT solutions, promoting critical thinking through designing efficient solutions and problem-solving in scalability.

CO7: Providing students with specialized skills in establishing wireless connectivity for IoT devices, fostering critical thinking through analyzing connectivity technologies and problem-solving in implementing wireless solutions effectively.

PO5. Research, Analytical Reasoning, and Ethical Conduct:

CO3: Developing students' research skills in identifying and resolving technical challenges, promoting analytical reasoning in diagnosing issues and ethical conduct in addressing problems effectively.

CO4: Encouraging students to research sensor integration for IoT devices, fostering analytical reasoning in selecting and connecting sensors ethically and conducting research on sensor functionalities.

CO5: Empowering students to conduct research on IoT application development, enhancing analytical reasoning in designing solutions and ethical conduct in deploying applications responsibly.

CO6: Guiding students to research scalable IoT solutions, promoting analytical reasoning in designing efficient systems and ethical conduct in creating sustainable solutions.

CO7: Prompting students to research wireless connectivity technologies, enhancing analytical reasoning in selecting appropriate technologies and ethical conduct in establishing secure and reliable wireless connections for IoT devices.

PO6. Communication, Collaboration, and Leadership:

CO4: Promoting communication skills in explaining sensor integration processes, encouraging collaboration in sensor interfacing projects, and developing leadership abilities in overseeing sensor connectivity tasks.

CO6: Encouraging students to communicate plans for scalable IoT solutions, promoting collaboration in designing sustainable projects, and developing leadership skills in overseeing the development of maintainable solutions.

CO7: Highlighting the need for clear communication in setting up wireless connections, fostering collaboration in implementing connectivity solutions, and developing leadership skills in managing wireless technology integration for IoT devices.

PO7. Digital Proficiency and Technological Skills:

CO3: Developing students' digital proficiency in diagnosing and resolving technical issues, improving their technological skills in problem-solving during Raspberry Pi development.

CO4: Fostering students' technological skills in sensor integration for IoT devices, enhancing their digital proficiency in connecting sensors and utilizing data from these devices effectively.

CO5: Empowering students to enhance their digital proficiency in designing and deploying IoT applications, improving their technological skills in creating functional and innovative IoT solutions.

CO6: Guiding students to improve their technological skills in designing scalable and maintainable IoT solutions, enhancing their digital proficiency in creating efficient and sustainable IoT projects.

CO7: Developing students' technological skills in establishing wireless connectivity for IoT devices, improving their digital proficiency in utilizing technologies like Wi-Fi, Bluetooth, and cellular networks to connect IoT devices wirelessly.

PO10. Autonomy, Responsibility, and Accountability:

CO2: Encourages students to take responsibility for connecting external hardware to the Raspberry Pi, promoting autonomy in exploring hardware integration and accountability for ensuring successful connections.

CO3: Developing students' autonomy in identifying and resolving technical challenges, fostering responsibility in troubleshooting issues independently, and instilling accountability for the outcomes of their problem-solving efforts.

CO4: Empowering students to take autonomous steps in integrating sensors with IoT devices, promoting responsibility in mastering sensor connectivity skills, and fostering accountability for the functionality of sensor-based projects.

CO5: Encouraging students to autonomously design and deploy IoT applications, instilling responsibility in creating innovative solutions and accountability for the successful implementation of their projects.

CO6: Guiding students to take responsibility for designing scalable and maintainable IoT solutions, promoting autonomy in creating efficient systems and fostering accountability for the sustainability of their projects.

CO7: Developing students' autonomy in setting up wireless connectivity for IoT devices, fostering responsibility in managing wireless technologies, and instilling accountability for establishing reliable wireless connections in IoT applications.