Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

Curriculum Structure and Syllabus

Master of Engineering (2025 Pattern)

M.E. - INTERNET OF THINGS (IoT) 2025 Pattern

(With effect from Academic Year 2025-26)

Contents

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PEO Program Educational Objectives

PO Program Outcomes

WK Knowledge and Attitude Profile

Master of Engineering in Internet of Things - 2025 Pattern

Preface by Board of Studies

Dear Students and Faculty Members,

We, the members of the Board of Studies of Electronics & Telecommunication engineering, are happy to present the syllabus for the Master of Engineering in **Internet of Things**, effective from the Academic Year 2025–26 (2025 Pattern).

The Internet of Things (IoT) has emerged as one of the most transformative and rapidly growing domains, playing a pivotal role in the convergence of electronics, communication, and computing technologies. This interdisciplinary field connects devices, systems, and applications, enabling intelligent decision-making and automation across diverse sectors such as smart cities, healthcare, industrial automation, agriculture, and transportation.

The curriculum has been carefully designed to provide learners with a strong foundation in IoT architecture, communication protocols, and data analytics, cloud computing, edge intelligence, cyber security, and system integration. It emphasizes a balance between theoretical understanding, skill development, and practical implementation, ensuring that graduates are equipped to address the challenges and opportunities of the connected world.

This syllabus revision particularly focuses on enhancing the knowledge component, skill-based learning, experiential activities, and project-driven approaches. It is aligned with the vision and objectives of Savitribai Phule Pune University, AICTE New Delhi, UGC, and accreditation agencies, while also being responsive to the latest technological advancements, innovations, and industry requirements. Students are provided with ample opportunities for self-learning through online platforms, industry projects, and research activities to strengthen their expertise and competencies.

We express our sincere gratitude to the faculty members, students, industry professionals, and all stakeholders who have contributed to the development of this curriculum. Their valuable insights and collaborative efforts have been instrumental in shaping a program that prepares students for leadership and innovation in the dynamic field of IoT.

Dr. Suresh Shirbahadurkar
Chairman
Board of Studies - Electronics & Telecommunication Engineering

Members of Board of Studies, Electronics & Telecommunication Engineering, Savitribai Phule Pune University, Pune	
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Curriculum Structure Semester -I

M.E (Internet of Things)

2025 Pattern

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme					Credits		
			Theory	Practical	CCE	End Sem	Term work	Oral	Total	Theory	Practical	Total
PCC-501-IOT	Program Core Course	Principles of IoT	4	-	50	50	-	-	100	4	-	4
PCC-502-IOT	Program Core Course	Embedded Physical Design of IoT	4	-	50	50	-	-	100	4	-	4
PCC-503-IOT	Program Core Course	Computational and Optimization Methods for IoT Systems	4	-	50	50	-	-	100	4	-	4
PCC-504-IOT	Program Core Course	VLSI Chip Design & Fabrication	4	-	50	50	-	-	100	4	-	4
PCC-505-IOT	Program Core Course -Lab	IOT Lab Practice –I	-	4	-	-	25	25	50	-	2	2
PEC-521-IOT	Program Elective Course	Elective I	3	-	50	50	-	-	100	3	-	3
PEC-522-IOT	Program Elective Course	Skill Based Laboratory -I	-	2	-	-	25	25	50	-	1	1
Total			**19**	**6**	**250**	**250**	**50**	**50**	**600**	**19**	**3**	**22**

List of Elective I Courses:

PEC-521A-IOT	IoT Security and Privacy
PEC-521B-IOT	Block Chain Technology
PEC-521C-IOT	AI & Machine Learning for IOT
PEC-521D-IOT	Wireless Sensor Networks for IOT

Savitribai Phule Pune University

Curriculum Structure Semester -II

M.E.- Internet of Things (IoT)

2025 Pattern

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme					Credits		
			Theory	Practical	CCE	End Sem	Term work	Oral	Total	Theory	Practical	Total
PCC-551-IOT	Program Core Course	Industrial Internet of things	4	-	50	50	-	-	100	4	-	4
PCC-552-IOT	Program Core Course	Embedded Technology and IOT	4	-	50	50	-	-	100	4	-	4
PCC-553-IOT	Program Core Course	Web Programming and Java	4	-	50	50	-	-	100	4	-	4
PCC-554-IOT	Program Core Course - Lab	IOT Lab Practice – II	-	4	-	-	25	25	50	-	2	2
PEC-571-IOT	Program Elective Course	Elective – II	3	-	50	50	-	-	100	3	-	3
PEC-572-IOT	Program Elective Course	Elective – III	3	-	50	50	-	-	100	3	-	3
SEM-581- IOT	Seminar	Seminar -I	-	4	-		25	25	50	-	2	2
Total			**18**	**8**	**250**	**250**	**50**	**50**	**600**	**18**	**4**	**22**

List of Elective II Courses:

PEC-571A-IOT	Cyber Security
PEC-571B-IOT	Energy and Power Management for IoT Devices
PEC-571C-IOT	Machine Learning
PEC-571D-IOT	Edge and Fog Computing

List of Elective III Courses:

PEC-572A-IOT	5G and IoT Integration
PEC-572B-IOT	IoT Protocols and Standards
PEC-572C-IOT	Cloud Architecture and Protocol
PEC-572D-IOT	Smart Healthcare IoT Systems

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Curriculum Structure Semester -III

M.E.- Internet of Things

2025 Pattern

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme					Credits		
			Theory	Practical	CCE	End Sem	Term work	Oral	Total	Theory	Practical	Total
RM-601-IOT	Research Methodology	Research Methodology	5	-	50	50	-	-	100	5	-	5
OJT-602-IOT	OJT / Internship	On Job Training / Internship	-	10	-	-	100	-	100	-	5	5
SEM-603-IOT	Seminar	Seminar – II	-	6	-	-	25	25	50	-	3	3
RPR-604-IOT	Research Project	Research Project - I	-	18	-	-	25	25	50	-	9	9
Total			**5**	**34**	**50**	**50**	**150**	**50**	**300**	**5**	**17**	**22**

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Curriculum Structure
Semester -IV
M.E.- Internet of Things (IoT) 2025 Pattern

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme					Credits		
			Theory	Practical	CCE	End Sem	Term work	Oral	Total	Theory	Oral	Total
SEM-651-IOT	Seminar	Seminar - III	-	8	-	-	50	50	100	-	4	4
RPR-652-IOT	Research Project	Research Project stage -II	-	36	-	-	150	50	200	-	18	18
Total			**-**	**44**	**-**	**-**	**200**	**100**	**300**	**-**	**22**	**22**

Savitribai Phule Pune University, Pune

Maharashtra, India

M.E.- Internet of Things (IoT) 2025 Pattern

Semester I

Savitribai Phule Pune University Master of Engineering (2025 Course) – (**Internet of Things**)		
PCC-501-IOT- Principles of Internet of Things		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 04 Hours/Week	04	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Basic knowledge about Python

Course Objectives: The course aims -

1. To introduce the fundamental concepts and architecture of the Internet of Things.
2. To study IoT communication models, protocols, and technologies.
3. To provide knowledge of sensors, actuators, and Raspberry Pi hardware for IoT applications.
4. To develop programming skills for implementing IoT solutions using Raspberry Pi.
5. To explore real-world IoT applications in domains such as smart homes, agriculture, and e-health

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

CO1: Understand the concepts of Internet of Things.

CO2: Understand IoT communication models and protocols, analyze different communication technologies

CO3: Interface sensors and actuators with Raspberry Pi for IoT applications.

CO4: Develop IoT applications using Raspberry Pi

CO5: Analyze real-world IoT applications in smart homes, agriculture, and e-health.

Course Contents

Unit I – Internet of Things (IoT) Introduction - (9 Hours)

Introduction of IoT: Definition and characteristics of IoT, Technical Building blocks of IoT, Device, Communication Technologies, Data, Physical design of IoT, IoT enabling technologies, IoT Issues and Challenges- Planning, Costs and Quality, Security and Privacy, Risks.

Unit II - Communication Protocols in IoT- (9 Hours)

IoT Protocols: MQTT, CoAP, XMPP and AMQT, IoT communication models, IoT Communication technologies: Bluetooth, BLE, Zigbee, Zwave, NFC, RFID, LiFi, Wi-Fi, Interfacing of wifi, RFID, Zigbee, NFC with development board.

Unit III - Interface sensors & actuators with Raspberry Pi for IoT applications- (9 Hours)

Roles of sensors & actuators, types and working of sensors, Overview of Raspberry Pi, its models, features, pin description, board setup, and basic configuration, selection criteria, and sensor interfacing for IoT applications.

Unit IV- Programming and IoT Applications with Raspberry Pi - (9 Hours)

Linux & Raspbian OS, basic Linux commands, Python programming, sensor interfacing (DHT11, PIR, Ultrasonic), IoT applications – web server, home automation, cloud connectivity, Node-RED basics.

Unit V- IoT Applications- (9 Hours)

IoT Applications Case studies are-

Smart Home: Characteristics of Smart Home - Smart Home Energy Management, Smart Appliances, Communication Technologies for Smart Homes, maintenance, security, challenges.

Smart Agricultural: characteristics and applications -Scarecrow, Smart Irrigation System, Crop Water Management, Integrated Pest Management, Sensor-based field and resource mapping, Remote equipment monitoring)

E-health: Characteristics of e-health and applications- monitoring of health parameters, smart medicine box, elderly people monitoring, challenges

Learning Resources:

Text Books:

1. Arshdeep Bhaga and Vijay Madisetti, "Internet of Things: A Hands-On Approach", Orient Black swan
2. Private Limited - New Delhi; First Edition (1 January 2015).
3. Simon Monk, "Programming Raspberry Pi", McGraw Hill TAB; 2nd edition (16 November 2015).
4. Olivier Hersent, David Boswarthick, and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2 nd Edition, Wiley Publications.

Reference Books:

1. Rajesh Singh, "Internet of Things with Raspberry Pi and Arduino", CRC Press 2020.
2. Simone Ciran," Internet of Things- Architectures, Protocols and Standards", WILEY,2018

Savitribai Phule Pune University Master of Engineering (2025 Course) – **(Internet of Things)**		
PCC-502-IOT Embedded Physical Design of IoT		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 04 Hours/Week	04	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Embedded Systems, VLSI Design, Digital Circuits, Microcontrollers

Course Objectives: The course aims -

1. To introduce principles of embedded physical design for IoT systems with focus on power, cost, and performance constraints.
2. To develop skills in integrating sensors, actuators, and communication interfaces through optimized hardware layouts.
3. To understand system-level trade-offs and analyze case studies of physical design challenges in real-world IoT applications.

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

- CO1: Explain fundamentals of embedded physical design in IoT systems.
- CO2: Analyze physical layer design parameters including power, clocking, and thermal constraints.
- CO3: Apply techniques for PCB, chip-level, and SoC-level IoT design.
- CO4: Integrate hardware modules (sensors, memory, processors, radios) with optimized physical design.
- CO5: Design and evaluate physical design solutions for industrial and smart IoT applications.

Course Contents

Unit I - Fundamentals of Embedded Physical Design in IoT- (9 Hours)

Basics of embedded physical design; role of physical design in IoT devices; design constraints – power, size, cost, performance; physical design flow for embedded IoT hardware; case study of IoT edge node physical design challenges.

Unit II - Physical Layer Design: Sensors, Actuators & Interfaces- (9 Hours)

Physical integration of sensors and actuators; packaging and interconnect technologies; signal integrity issues; hardware interfaces – I2C, SPI, UART, CAN, GPIOs from physical design perspective; clock distribution, synchronization, and noise management.

Unit III - PCB and System-on-Chip Design for IOT- (9 Hours)

PCB design principles for IoT devices – single and multi-layer boards; routing techniques for RF and low-power IoT modules; SoC design for IoT – low-power architectures, memory integration; power optimization, leakage reduction, and thermal management in embedded hardware.

Unit IV- Embedded Physical Design for Communication & Networking- (9 Hours)

Physical design aspects of wireless IoT protocols – BLE, ZigBee, LoRa, NB-IoT, Wi-Fi; antenna design for compact
IoT devices; power-aware RF transceiver design; EMI/EMC considerations; layout and shielding techniques for reliable IoT communication.

Unit V- Applications & Case Studies- (9 Hours)

Industrial IoT: rugged and reliable hardware design; healthcare IoT: low-power, miniaturization, and biocompatibility challenges; wearable IoT devices: flexible electronics and packaging; energy harvesting-based IoT hardware; case study – end-to-end physical design of a smart sensor node.

Learning Resources:

Text Books:

1. Jan Rabaey et al., *Digital Integrated Circuits: A Design Perspective*, Pearson.
2. Raj Kamal, *Internet of Things: Architecture and Design Principles*, McGraw Hill.
3. Mohammad Ali Mazidi, *Embedded Systems Design and Applications with ARM Cortex-M*, Pearson.

Reference Books:

1. David Money Harris, *Digital Design and Computer Architecture*, Morgan Kaufmann.
2. Krzysztof Iniewski, *Smart Sensors for Industrial IoT*, CRC Press.
3. Thomas R. Kurfess, *Manufacturing, Physical Design, and IoT Systems Integration*, Wiley.

Online Resources- MOOC / NPTEL / Coursera Courses:

1. NPTEL Course "Embedded Systems Design" https://nptel.ac.in/courses/117/106/117106030/
2. NPTEL Course "IoT Systems and Applications" https://nptel.ac.in/courses/106/105/106105195/
3. Coursera Course "Internet of Things Specialization (UC San Diego)" https://www.coursera.org/specializations/internet-of-things

Savitribai Phule Pune University Master of Engineering (2025 Course) – **(Internet of Things)**		
PCC- 503-IOT -Computational and Optimization Methods for IoT Systems		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 04 Hours/Week	04	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: to handle the complex mathematical models and programming-intensive nature of the course, bridging the gap between theoretical knowledge and practical IoT applications.

Course Objectives: The course aims –

1. To formulate and model real-world IoT challenges (such as energy consumption and network latency) using mathematical and computational approaches.
2. To apply classical and advanced optimization methods to develop efficient and scalable IoT solutions.
3. To design algorithms and protocols that address IoT constraints like limited power, memory, and processing capabilities.
4. To evaluate the performance and efficiency of computational techniques in distributed IoT environments.
5. To utilize modern computational tools and simulation platforms to implement and test optimization strategies for IoT applications.

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

- CO1: Students can articulate a given IoT problem as a well- defined mathematical optimization problem, identifying objective functions, variables, and constraints.
- CO2: Students can implement and apply a range of algorithms, including linear programming, dynamic programming, and metaheuristics (e.g., genetic algorithms, particle swarm optimization), to optimize IoT system performance.
- CO3: Students can design and evaluate energy-aware routing protocols, efficient data aggregation schemes, and optimal task scheduling algorithms for IoT devices and networks.
- CO4: Students can critically analyze and compare the trade-offs between different optimization strategies in terms of computational complexity, solution quality, and resource utilization.
- CO5:: Students are skilled in using simulation tools and programming languages (like Python) to implement and validate their computational and optimization solutions for practical IoT scenarios such as smart cities, precision agriculture, or industrial automation.

Course Contents

Unit I - Mathematical Foundations for IoT (9 Hours)

Linear Algebra: Concepts such as matrix operations, determinants, and eigenvectors. Emphasis on Singular Value Decomposition (SVD) and Principal Component Analysis (PCA) for data reduction and feature extraction from vast amounts of sensor data. Probability and Statistics: Advanced topics including stochastic processes, queuing theory, and Bayesian inference. Numerical Methods: Numerical solution of differential equations, interpolation, and regression analysis, focusing on their use for sensor calibration and data reconstruction.

Unit II - Classical and Deterministic Optimization (9 Hours)

Unconstrained Optimization: In-depth study of gradient descent, Newton's method, and conjugate gradient algorithms for finding local minima in cost functions. Constrained Optimization: Introduction to Lagrange multipliers and the Karush-Kuhn-Tucker (KKT) conditions for solving optimization problems with equality and inequality constraints. Linear Programming: The Simplex method and duality theory. Applications will include optimizing network flow, assigning tasks to devices, and managing energy budgets. Dynamic Programming: The principle of optimality and its application to solving sequential decision-making problems, such as optimal routing and task scheduling in IoT networks.

Unit III - Optimization in Distributed and Networked Systems (9 Hours)

Network Optimization: Algorithms for energy-efficient routing (e.g., Dijkstra's variant for energy cost), load balancing, and Quality of Service (QoS) in wireless sensor networks and Low-Power Wide-Area Networks (LPWANs). Edge and Fog Computing: Optimization models for task offloading and resource allocation between edge devices and cloud servers to minimize latency and bandwidth consumption. Data Aggregation and Fusion.

Unit IV - Computational Intelligence and Heuristic Methods (9 Hours)

Metaheuristic Algorithms: A study of Genetic Algorithms (GAs), Simulated Annealing, and Particle Swarm Optimization (PSO). These are used for problems where an optimal solution is computationally intractable, such as sensor placement or complex routing. Machine Learning and Optimization: The role of optimization in training machine learning models for IoT applications like anomaly detection, predictive maintenance, and pattern recognition. Reinforcement Learning: An introduction to RL frameworks for autonomous decision- making in a dynamic IoT environment, such as a self-configuring smart home or an autonomous vehicle.

Unit V - Security, Privacy, and Practical Implementation (9 Hours)

Security & Privacy Optimization: Optimizing cryptographic key distribution, designing secure routing protocols, and using optimization to identify and mitigate cyber threats in real-time. Simulation and Emulation: Hands-on labs using tools like NS-3 or GNS3 for network simulation and Tensor Flow Lite for implementing machine learning models on resource-constrained devices like Raspberry Pi or ESP32. Case Studies: A project- based component where students apply the concepts to a real-world problem. Examples include optimizing an agricultural sensor network, designing a smart grid energy management system, or creating a healthcare monitoring system with a focus on data privacy.

Learning Resources

Text Books:

1. Mathematics for Machine Learning" by Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong
2. Convex Optimization" by Stephen Boyd and Lieven Vandenberghe
3. Distributed Optimization and Statistical Learning via the Alternating Direction Method of Multipliers" by Stephen Boyd et al

Reference Books:

1. Introduction to Linear Algebra" by Gilbert Strang
2. Numerical Methods for Engineers" by Steven C. Chopra and Raymond P. Canale.
3. Numerical Recipes: The Art of Scientific Computing" by William H. Press et al
4. The Internet of Things: From Machine-to-Machine to the Internet of Everything by P. H. E. van der Berg et al.
5. Pattern Recognition and Machine Learning by Christopher Bishop (for Module 4)
6. For practical applications: Relevant IEEE and ACM journal papers, tutorials on platforms like Timmy, and open-source documentation for IoT hardware and software
7. *Hands-On Artificial Intelligence for IoT* by Rajesh Kumar Dhanaraj and Balamurugan Balusamy.

Savitribai Phule Pune University Master of Engineering (2025 Course) – **(Internet of Things)**		
PCC-504-IOT -VLSI Chip Design and Fabrication		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 04 Hours/Week	04	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Digital Electronics, VLSI Design

Course Objectives: The course aims to:

1. To understand Verilog and its use to the design various applications.
2. To analyze HDL design flow and EDA tools.
3. To analyze different aspects of testing and fault models.
4. To understand the insights of chip design such as epitaxy and lithography.
5. To understand the insights of chip design such as ion implantation and metallization.

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

- CO1: Analyze and implement basic Verilog coding.
- CO2: Understand the IC design flow and EDA tools
- CO3: Understand the AISC timing analysis and different fault models.
- CO4: Understand the major steps in the fabrication process of VLSI circuits
- CO5: Apply implantation process for VLSI devices and discuss the metallization.

Course Contents

Unit I - Design with HDL - (9 Hours)

Basics of Verilog: Typical HDL-flow, why Verilog HDL, trends in HDLs. Gate-Level Modelling: Modelling using basic Verilog gate primitives, description of and/or and buffer/not type gates, rise, fall and turn- off delays, min, max, and typical delays. Behavioral Modelling: Structured procedures, initial and always, blocking and non- blocking statements, delay control, generate statement, event control, conditional statements, Multiway branching, loops, sequential and parallel blocks.

Unit II - ASIC Design Part I - (9 Hours)

Types of ASIC and Comparisons, ASIC Design Flow, Logic Synthesis, Simulation, EDA Tools, ASIC Physical Design: Architecture Design, Physical Design, CAD Tools, System partitioning, Partitioning Strategies, Floor planning, Placement, Routing.

Unit III - ASIC Design Part II - (9 Hours)

ASIC Timing Analysis: Static timing analysis, Timing constraints, Delay estimation, ASIC Verification and Testing: Different Chip Test Methods, Fault Models, Scan Test, Partial Test, Digital scan standards, BIST architecture, BILBO, Boundary Scan, Self-Test, JTAG, ATPG

Unit IV- Chip Design - (9 Hours)

Crystal Growth and Wafer Preparation: Introduction, Electronic-Grade Silicon, Czekalski Crystal Growing. Epitaxy: Introduction, Vapor-Phase Epitaxy.

Lithography: Introduction, Optical Lithography, Electron Lithography, X-ray Lithography, Ion Lithography.

Reactive Plasma, Etching: Introduction, Plasma Properties, Feature-Size Control and Anisotropic Etch Mechanisms, Reactive Plasma-Etching Techniques and Equipment.

Unit V- Chip Fabrication - (9 Hours)

Ion Implantation: Introduction, Range Theory, Implantation Equipment, Annealing, Shallow Junctions, High-Energy Implantation.

Metallization: Introduction, Metallization Applications, Metallization Choices, Physical Vapor Deposition, Patterning, Metallization problems.

Learning Resources

Text Books:

1. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Pearson Education, Second Edition.
2. S.M. Sze, VLSI Technology, McGraw-Hill, 2017, 2nd Edition (Indian).

Reference Books:

1. Smith Michael, “Application Specific Integrated Circuits” Pearson Education
2. S.K. Gandhi, “VLSI Fabrication Principles”, John Willey &Sons

Savitribai Phule Pune University
Master of Engineering (2025 Course) – **(Internet Of Things)**

PCC-505 IOT–IoT Lab Practice –I

Teaching Scheme	Credits	Examination Scheme
Theory : 04 Hours/Week	02	**Term work**: 25 Marks **Oral**: 25 Marks

Course Objectives: The course aims to:

1. To understand core concepts and protocols of IoT.
2. To design and implement embedded systems for IoT.
3. To apply computational and optimization methods for IoT systems.
4. To learn chip design flow.

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

- CO1: Design and model IoT architectures, embedded systems, and computational frameworks for real-world applications.
- CO2: Analyze IoT solutions with respect to scalability, constraints, optimization, and performance.
- CO3: Implement and validate IoT prototypes using modern tools, simulations, and optimization techniques.
- CO4: Design chip & simulate using EDA tools for specific applications.

Lab Practical

Guidelines:
1. IoT Laboratory-I Experiments based on programme core courses.
2. Use available software/hardware.

Part A: Principle of Internet Of Things (Any 2)

1. Design and develop a Zigbee-based device communication system using Raspberry Pi for remote LED control.
2. Implement and analyze an obstacle detection system using IR sensor and Raspberry Pi with LED indication.
3. Design and develop a smart streetlight control system using Raspberry Pi with adaptive light sensing.
4. Develop and evaluate a weather monitoring system using Raspberry Pi with humidity, temperature, and raindrop sensors.
5. Implement and test traffic signal control and smart health monitoring applications using Raspberry Pi/Arduino with alert mechanisms.

Part B: Embedded Physical Design of IoT (Any 2)

1. Design and implement an embedded sensor node using Arduino/ESP32 — interface temperature and light sensors, read data, and send via serial/Wi-Fi.
2. Develop a low-power firmware routine for IoT devices — implement sleep/wake modes on ESP32/Arduino and measure power savings.
3. Design and test signal conditioning and ADC interface — build an amplifier/filter for a sensor signal and acquire it with MCU ADC.
4. PCB layout and prototype fabrication of a simple IoT breakout board — create schematic and PCB (KiCad), fabricate a single-board prototype and verify basic I/O.

Part C: Computational and Optimization Methods for IoT Systems (Any 2)

1. Implement linear programming in Python to minimize energy consumption of IoT devices.
2. Write a Python program to schedule IoT tasks using dynamic programming.
3. Simulate shortest-path routing for IoT networks using Dijkstra's algorithm.
4. Apply Genetic Algorithm in Python for optimal sensor placement in a smart environment.

Part D: VLSI Chip design and fabrication (Any 2)

1. Write Verilog code and test bench to simulate, synthesis for the 4-bit counter [Synchronous & Asynchronous counter].
2. Write Verilog code and test bench to simulate, synthesis for 4/8-bit Magnitude Comparator
3. Write Verilog code and test bench to simulate, synthesis for counter with given input clock and check whether it works as clock divider performing division of clock by 2, 4, 8 and 16.
4. Write Verilog code and test bench to simulate, synthesis Mealy and Moore Sequence Detector to detect Sequence. ------11101-----.
5. Verify the functionality of the code Model in Verilog for a full adder and add functionality to perform logical operations of XOR, XNOR, AND, OR gates. Write test bench with appropriate input patterns to verify the modeled behavior.

Savitribai Phule Pune University Master of Engineering (2025 Course) – **(Internet of Things)**		
PEC-521A-IOT - IOT Security & Privacy (Elective-I)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Wireless Communication Technology

Course Objectives: The course aims -

1. To introduce the architecture of IoT systems, their unique constraints, and the importance of security and privacy in IoT environments.
2. To provide an in-depth understanding of IoT threat models, vulnerabilities, cryptographic techniques, and secure communication mechanisms.
3. To enable students to analyze, design, and evaluate secure IoT solutions by integrating network, privacy, trust, and regulatory considerations.

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

- CO1: Explain IoT architecture, communication models and device characteristics. Also can identify fundamental security and privacy challenges.
- CO2: Analyze IoT threat models, vulnerabilities, and attack surfaces to propose basic defensive strategies.
- CO3: Apply cryptographic techniques, authentication mechanisms, and access control models to secure IoT systems.
- CO4: Design secure network infrastructures, backend systems, and privacy-preserving frameworks for IoT.
- CO5: Evaluate emerging IoT security trends, case studies, and regulatory standards to ensure compliance and future readiness.

Course Contents

Unit I - IoT Architecture, Ecosystem, and Security Basics - (8 Hours)

IoT ecosystem, IoT architecture layers, IoT communication models, IoT device characteristics, resource constraints in IoT, heterogeneity and interoperability issues, introduction to IoT security, privacy concerns in IoT, overview of security challenges and solutions.

Unit II - Threat Models, Vulnerabilities and Attacks in IoT- (8 Hours)

IoT threat surfaces, attack vectors in IoT devices and networks, sensor-level attacks, RFID vulnerabilities, routing and denial-of-service attacks, firmware and hardware exploitation, physical security threats, side-channel attacks, privacy breaches, attack modeling and classification frameworks.

Unit III - Cryptography, Authentication, and Access Control - (8 Hours)

Lightweight cryptography for IoT, symmetric and asymmetric cryptographic techniques, key establishment and management, device and user authentication, secure communication protocols (TLS, DTLS, CoAP, MQTT), identity management systems, role-based and attribute-based access control models, capability-based security mechanisms.

Unit IV- Network, Infrastructure and Privacy Security - (8 Hours)

Security across IoT communication layers (physical, link, network, transport, application), secure M2M communication, intrusion detection and prevention in IoT networks, cloud and fog security, backend infrastructure security, secure data storage, secure resource management, database protection, privacy risks in IoT data collection, privacy-enhancing technologies (anonymization, pseudonymization, differential privacy), privacy-aware data aggregation, blockchain-based privacy approaches, trust models, policy-based trust management, consent frameworks.

Unit V- Emerging Trends, Case Studies, and Regulations - (8 Hours)

AI/ML-based intrusion detection in IoT, reinforcement learning for IoT security, edge and fog security models, zero-trust security architecture, IoT security testbeds and frameworks, smart home security, industrial IoT security, healthcare IoT security, IoT standards, regulatory policies, and legal compliance frameworks.

Learning Resources

Text Books:

1. Souvik Pal, Vicente García Díaz, and R. P. Mohanty, "IoT: Security and Privacy Paradigm", 1st Edition, CRC Press, 2022.
2. Brij B. Gupta, "Internet of Things Security: Principles, Applications, Attacks and Countermeasures", 1st Edition, CRC Press, 2020.
3. B. B. Gupta, M. Quamina, and N. Kumar, "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations", 1st Edition, Springer, 2020.

Reference Books:

1. Brij B. Gupta, "A Beginner's Guide to Internet of Things Security: Attacks, Applications, Authentication Fundamentals and Security", 1st Edition, CRC Press, 2020.
2. K. Loupes, "Holistic IoT Security, Privacy and Safety", 1st Edition, Now Publishers, 2025.
3. H. Suo, J. Wan, C. Zou, and J. Liu, "Security in the Internet of Things: A Review", 1st Edition, Springer, 2012.

Savitribai Phule Pune University Master of Engineering (2025 Course) – **(Internet of Things)**		
PEC-521B - IOT – Block Chain Technology (Elective-I)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory :03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Computer Networks, Data Structures and Algorithms, Distributed Systems

Course Objectives: The course aims to:

1. To understand the fundamental concepts, architecture and cryptographic principles underlying blockchain and distributed ledger technologies.
2. To explore various consensus mechanisms to achieve secure and reliable agreement in decentralized systems.
3. To design and develop smart contracts, decentralized applications (DApps)
4. To evaluate the application of blockchain frameworks in enterprise environments, decentralized finance (DeFi).
5. To explore advanced trends and research directions for integrating blockchain with IoT, AI and Cloud technologies.

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

- **CO1: A**nalyze the evolution, architecture, and cryptographic foundations of blockchain systems.
- **CO2:** Design and evaluate smart contracts and decentralized applications (Dapps),
- **CO3:** Apply enterprise blockchain frameworks to evaluate cross-chain interoperability solutions.
- **CO4:** Assess decentralized finance (DeFi) applications and challenges in blockchain adoption.
- **CO5:** Investigate emerging blockchain research trends, integration with IoT, AI, and Cloud technologies.

Course Contents

Unit I - Blockchain Foundations & Cryptography- (9 Hours)

Evolution of blockchain: Bitcoin to Web3, Blockchain architecture: Blocks, chains, nodes, P2P network, Permissioned vs. permissionless blockchains, Distributed Ledger Technologies (DLT), Cryptographic principles: Hashing, Merkle Trees, Digital Signatures, Zero-Knowledge Proofs (zkSNARKs, zkSTARKs), Consensus mechanisms: Proof of Work (PoW), Proof of Stake (POS), Delegated Proof of Stake (Dapos), Practical Byzantine Fault Tolerance (PBFT), Directed Acyclic Graphs (DAG)

Unit II - Smart Contracts & Decentralized Applications (Dapps)- (7 Hours)

Smart contract fundamentals and design principles, Economic and legal aspects of smart contracts, Oracles and hybrid contracts: Conceptual overview, Security considerations: Common vulnerabilities, Mitigation strategies, Gas costs and optimization concepts.

Unit III - Enterprise Blockchain Frameworks & Cross-Chain Interoperability - (8 Hours)

Hyperledger Fabric, Corda, Quorum — architecture and use-cases, Cross-chain interoperability: Polka dot, Cosmos — concepts and industry relevance, Case studies and real-world examples.

Unit IV- Decentralized Finance (DeFi), NFTs & Regulations - (7 Hours)

DeFi ecosystem, NFTs, DAOs, CBDCs — trends and conceptual frameworks, Regulatory frameworks: GDPR, KYC and AML, compliance challenges, Sustainability and green blockchain initiatives.

Unit V- Advanced Trends-IoT, AI, Cloud Integration - (7Hours)

Blockchain for IoT: Secure device identity, data integrity, Blockchain for AI: Data provenance, AI model trustworthiness, Blockchain for Cloud: case study of Decentralized storage, edge computing integration, Privacy-enhancing techniques: Mixers, ring signatures, confidential transactions.

Learning Resources

Text Books:

1. Imran Bashir, Mastering Blockchain, 4th Edition, Packet Publishing, 2023.
2. Daniel Drescher, Blockchain Basics*:* A Non-Technical Introduction in 25 Steps, 1st Edition, A press, 2017.
3. Andreas M. Antonopoulos, Gavin Wood, Mastering Ethereum: Building Smart Contracts and Dapps*,* 1st Edition, O'Reilly Media, 2018.
4. Ritesh Modi, Solidity Programming Essentials*,* 2nd Edition, Packet Publishing, 2022.
5. Nitin Gaur, Luc Desrosiers, Venkatraman Ramakrishna, Petr Novotny, Anthony O'Dowd, *Hands-On* Blockchain with Hyperledger: Building Decentralized Applications with

Hyperledger Fabric and Composer, 1st Edition, Packet Publishing, *2018.*
6. Nakul Shah, Blockchain for Business with Hyperledger Fabric, 1st Edition, Packet Publishing, 2018.
7. Arshdeep Bhaga, Vijay Madisetti, Blockchain Applications: A Hands-On Approach, *1st Edition, VPT, 2017.*

Reference Books:

1. Roberto Infante, Building Ethereum Dapps, 1st Edition, Packet Publishing, 2019.
2. Kevin Solorio, Randall Kanna, David H. Hoover, Hands-On Smart Contract Development with Solidity and Ethereum: From Fundamentals to Deployment, 1st Edition, O'Reilly Media, 2019.
3. Dajani Mohanty, Corda in Action, 1st Edition, Manning Publications, 2021.

SWAYAM/ MOOC / eBOOKS

1. https://onlinecourses.nptel.ac.in/noc22_cs44/preview
2. https://onlinecourses.nptel.ac.in/noc19_cs63/preview
3. https://onlinecourses.nptel.ac.in/noc20_cs01/preview
4. https://onlinecourses.swayam2.ac.in/aic21_ge01/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – **(Internet Of Things)**		
PEC-521C-AI & Machine Learning for IOT (Elective-I)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Computer Networks, Basics of Linear Algebra, Basics of Python Programming Language.

Course Objectives: This course introduces core AI & ML concepts relevant to Internet of Things (IoT) Applications.

1. To gain a fundamental understanding of Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT).
2. To understand data processing and analytics methods specific to IoT-generated data.
3. To apply AI techniques—including ML and Deep Learning (DL)—for enhancing data analysis, decision-making, and automation in IoT systems.
4. To explore strategies for deploying AI solutions across edge and cloud platforms in IoT architectures.
5. To examine domain-specific applications of AI in IoT through real-world case studies and practical insights.

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

- CO1: Understand the fundamental concepts of Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT)..
- CO2: Analyze and process IoT-generated data using appropriate data analytics techniques.
- CO3: Design and implement AI models, including ML and Deep Learning (DL) techniques, to support intelligent decision-making and automation in IoT systems.
- CO4: Evaluate and deploy AI solutions across edge and cloud computing platforms within IoT architectures.
- CO5: Assess real-world case studies to identify effective AI applications in various IoT domains such as healthcare, smart cities, and industrial automation.

Course Contents

Unit I - Understanding the Pillars of Intelligent Systems: AI, ML, and IoT - (9 Hours)

IoT Fundamentals: Evolution, architecture (cloud, edge, fog), functional blocks (Sensors, Actuators) and communication Modules.

AI & ML Fundamentals: Introduction to AI/ML concepts, programming languages (Python), algorithms, and frameworks

Unit II - Data Processing and Analytics in the Internet of Things- (9 Hours)

IOT Data Pre-processing: Data Preparation for Predictive Maintenance Modeling, Cleaning and Standardizing IoT Data, Applying Advanced Data Exploration Techniques

Feature Engineering: Exploring Feature Engineering, Applying Feature Selection Techniques, Feature set selection using ML, Machine learning for Internet of Things data analysis

Unit III - AI-Driven Methods for IoT - (9 Hours)

Machine learning (ML) methods for IoT Applications: Decision Trees (DTs), Support Vector Machines (SVMs), Bayesian theorem-based algorithms, k-Nearest neighbor (KNN), Random Forest (RF), Association Rule (AR) algorithms, Ensemble learning (EL), k-Means clustering, Principal component analysis (PCA)

Deep learning (DL) methods for IoT Applications: Convolutional neural networks (CNNs), Recurrent neural networks (RNNs), Deep autoencoders (AEs), Restricted Boltzmann machines (RBMs), Deep belief networks (DBNs), Generative adversarial networks (GANs), Ensemble of DL networks (EDLNs)

Unit IV - AI Deployment in Edge and Cloud IoT Architectures- (9 Hours)

Edge Computing on IOT Devices, IOT Based Smart Buildings, Distributed Machine Learning, Machine Learning Accelerator, Machine Learning Model Optimization, **Least-Squares-Solver for Shallow Neural Network:** Introduction, Algorithm Optimization, Hardware Implementation.

Unit V- AI, ML and IoT: Applications and Case-Based Insights - (9 Hours)

Applications of AI, ML and IOT,
Case Studies: IOT for Agriculture, Remote Patient Monitoring, Smart City, Smart Transportation, IOT Security using ML

Learning Resources

Text Books:

1. Hatano Huang, Hao Yu, "Compact and Fast Machine Learning Accelerator for IoT Devices, "Edition: 1st ed. Publisher: Springer Singapore Year: 2019ISBN: 978-981-13-3323-
2. Ethem ALPAYDIN, "Introduction to Machine Learning", The MIT Press, October 2004, ISBN 0-262-01211-1
3. Olivier Hersent, David Boswarthick, and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2 nd Edition, Wiley Publications.
4. Arshdeep Bhaga and Vijay Madisetti, "Internet of Things: A Hands-On Approach", Orient Black swan Private Limited - New Delhi; First Edition (1 January 2015).

Reference Books:

1. Puneet Mathur, "IoT Machine Learning Applications in Telecom, Energy, and Agriculture, With Raspberry Pi and Arduino Using Python", ISBN 978-1-4842-5549-0
2. Tom M. Mitchell, "Machine Learning", McGraw-Hill Science/Engineering/Math; (March 1, 1997) ISBN: 0070428077
4. Neeraj Kumar, Aaisha Makkar, "MACHINE LEARNING IN COGNITIVE IOT", https://www.routledge.com/Machine-Learning-in-Cognitive-IoT/Kumar-Makkar/p/book/9780367359164 ISBN 9780367359164 Published June 1, 2020 by CRC Press
5. Trevor Hastie Robert Tibshirani Jerome Friedman, "The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Second Edition, Springer Series in Statistics, Feb 2009
6. Nicolas Modrzyk, "Real-Time IoT Imaging with Deep Neural Networks - Using Java on the Raspberry Pi 4" , Après Publication, Year: 2020, ISBN: 9781484257210, 978148425722

Savitribai Phule Pune University Master of Engineering (2025 Course) – **(Internet of Things)**		
PEC-521D -IOT: Wireless Sensor Network for IoT (Elective-I)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Basics of IoT

Course Objectives: The course aims -

1. To give insight to various platforms needed for Embedded Technologies and IoT.
2. To provide in-depth knowledge of Wireless Sensor Networks (WSNs) and their role in IoT systems.
3. To analyze architectures, protocols, and design considerations in large-scale WSN deployments.
4. To study MAC, routing, and synchronization issues specific to IoT-enabled WSNs.
5. To understand energy-efficient design strategies and optimization techniques for WSN nodes.
6. To explore integration of WSNs with IoT network architectures, edge, and cloud layers.

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

- CO1: Understand advanced WSN concepts, architectures, and enabling technologies for IoT.
- CO2: Apply appropriate MAC and routing protocols for designing energy-efficient and scalable IoT-based WSN solutions for given scenarios.
- CO3: Analyze the performance of addressing, synchronization, and data management techniques in different WSN environments.
- CO4: Design IoT network architectures incorporating WSN nodes and gateways.
- CO5: Evaluate performance and optimization issues in WSN-enabled IoT systems.

Course Contents

Unit I - Overview of Wireless Sensor Networks for IoT- (6 Hours)

Introduction of WSN, Characteristics of WSNs vs. traditional networks, Design constraints and challenges: scalability, heterogeneity, QoS, fault tolerance, Scope of WSN in IoT applications, Enabling technologies for WSNs in IoT

Unit II - Sensor Node and Network Architectures- (8 Hours)

Advanced single-node architecture: sensing, computation, communication, and power units, Hardware components and energy consumption models, Operating systems and execution environments (Tinos, Contiki, RIOT) , Network topologies: star, mesh, hybrid architectures.

Unit III - Communication and MAC Protocols- (8 Hours)

Physical layer considerations and transceiver design, MAC protocols: contention-based (CSMA, PAMAS), schedule-based (TDMA, FDMA, CDMA, LEACH), Low duty cycle protocols and wake-up radio concepts, Standards relevant to IoT: IEEE 802.15.4, 802.15.4e TSCH, 6LoWPAN

Unit IV-Routing, Addressing, and Synchronization - (8 Hours)

Routing protocols: flat, hierarchical, location-based approaches, Energy-efficient routing protocols (LEACH, PEGASIS, geographic routing), Address and name management in WSNs for IoT, Synchronization issues and techniques in distributed sensor networks, Security challenges: confidentiality, authentication, resilience

Unit V-Data Management, Reliability, and Integration with IoT Architectures - (10 Hours)

Data aggregation, fusion, and in-network processing, Gateway concepts and WSN–IoT integration strategies, IoT network architectures: oneM2M, IoT World Forum models, Edge and fog computing with WSNs: performance trade-offs, Reliability and fault tolerance mechanisms in WSNs, Optimization goals: energy efficiency, lifetime maximization, QoS trade-offs, Future trends: AI/ML integration in WSNs, cross-layer design approaches

Learning Resources

Text Books:

1. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2005.
2. Feng Zhao & Leonidas J. Guibas, "Wireless Sensor Networks – An Information Processing Approach" , Elsevier, 2007.
3. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Jerome Henry, Robert Barton, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for IoT", Cisco Press, 2017.

Reference Books:

1. Ian F. Akyildiz and Mehmet Can Vuran, "Wireless Sensor Networks", John Wiley & Sons, 2010.
2. Kazem Sohrab, Daniel Minoli & Tayeb Znati, "Wireless Sensor Networks: Technology, Protocol"s, and Applications, Wiley, 2007.
3. Raj Kamal, "Internet of Things: Architecture and Design Principles" , McGraw Hill Education, 2017.

Savitribai Phule Pune University Master of Engineering (2025 Course) – **(Internet of Things)**		
PEC-521-IOT- Skill Based Laboratory - I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 02 Hours/Week	01	**Term Work:** 25 Marks **Oral:** 25 Marks

Prerequisite Courses: Program Elective Course

Guidelines for Skill Based Laboratory

Skill Based Laboratory are based on the electives chosen by the students.

List of Assignments

Select practical experiments from Part A (any 3) and Mini- Project from Part B.

Part A- IoT Security & Privacy

1. Implement symmetric and asymmetric encryption (AES, RSA) on IoT data collected from sensors and analyse performance overhead.
2. Configure secure communication between IoT devices using TLS/DTLS over MQTT or CoAP.
3. Develop and test a lightweight authentication mechanism (e.g., token-based authentication) for an IoT edge device.
4. Demonstrate role-based or attribute-based access control for IoT devices in a smart home/industrial setup.
5. Simulate common IoT network attacks (e.g., DoS, replay attack, spoofing) and evaluate defense mechanisms.
6. Implement privacy-preserving data aggregation using anonymization/pseudonymization techniques for IoT sensor data.

Part A –Blockchain

1. Write a program to simulate a blockchain with multiple blocks using hashing and a simple Proof-of-Work mechanism.
2. Design and deploy a simple smart contract using Solidity on Remix IDE and test it on an Ethereum test network.
3. Simulate a consensus mechanism using Python or an online tool and demonstrate how nodes agree on the next block even in the presence of faulty nodes.

Part A – AI & Machine Learning For IOT

1. Pre-process IoT sensor data and apply feature selection.
2. Implement classification using Decision Tree / Random Forest / SVM.
3. Apply clustering (k-Means / DBSCAN) on IoT datasets.
4. Implement CNN / RNN for IoT applications.
5. Deploy a lightweight ML model on Raspberry Pi / ESP32.
6. Train an ML model for intrusion detection using IoT security data.

Part A- Wireless Sensor Network for IoT

1. Simulation of different WSN network topologies (star, mesh, hybrid).
2. Implementation of CSMA and TDMA-based MAC protocols.
3. Energy-efficient routing using LEACH or PEGASIS.
4. Data aggregation and fusion in a WSN test scenario.
5. Integration of WSN with IoT cloud using a gateway (e.g., MQTT/6LoWPAN).

Part B: Mini project

1. **Blockchain** - To design and implement a blockchain-based voting system where votes are securely stored, tamper-proof, and transparently counted using Ethereum smart contracts
2. **Wireless Sensor Network for IoT** – Design and implement an energy-efficient routing protocol (LEACH/PEGASIS) for a WSN testbed and evaluate performance.
3. **IoT Security & Privacy** – Develop a secure IoT healthcare monitoring system with encrypted communication and role-based access control.
4. **AI & Machine Learning for IoT** – Build and deploy a machine learning-based predictive maintenance model using IoT sensor data on an edge device.

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Maharashtra, India

ME (2025 Course) – Internet of Things

Semester II

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet of Things**		
PCC-551-IOT- Industrial Internet of things		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 04 Hours/Week	04	**CCE**: 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Fundamentals of Communication and Computer Network, Computer Network Technology, Internet of Things.

Course Objectives: The course aims -

1. To understand what is Industrial Internet of Things.
2. To Describe architecture, Design, underlying technologies, Security and Standards.
3. To understand industrial application of IoT

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

CO1: Explain what is Industrial Internet of Things.
CO2: Explain architecture and underlying addressing techniques
CO3: Understand the Data Acquisition and Processing techniques.
CO4: Understand IIOT Security and Standards.
CO5: Understand industrial application of IoT

Course Contents

Unit I - INTRODUCTION TO INDUSTRIAL IoT - (9 Hours)

What is the Internet of Things? Internet of Things Definitions and Frameworks: IoT Definitions, IoT Architecture, IoT levels and Deployment templates: Level 1 to Level 5, IoT Enabling Technologies: WSN, cloud computing, Big data Analytics, communication Protocols, Embedded systems, Overview of IoT vs. IIOT, Key characteristics and requirements of IIOT, IIOT reference architectures (RAMI 4.0, IIRA)

Unit II - IIOT COMMUNICATION, ADDRESSING AND NETWORKING- (9 Hours)

The one M2M IoT Standardized Architecture, The IoT World Forum (IOTWF) Standardized Architecture, A Simplified IoT Architecture, IoT protocol stack, Communication protocols for IIOT: MQTT, CoAP, OPC-UA, DDS, Modbus, PROFINET, Address Capabilities, IPv6 Protocol Overview, IPv6 Tunneling, IPsec in IPv6, Header Compression Schemes, Quality of Service in IPv6, Industrial networking standards (Ethernet/IP, Wireless HART, 6LoWPAN), Edge, Fog, and Cloud computing in IIOT, Time-sensitive networking (TSN).

Unit III - DATA ACQUISITION AND PROCESSING - (9 Hours)

Data acquisition from industrial machines and sensors, SCADA systems and PLCs integration with IoT, Data storage (time-series databases, cloud storage), Introduction to cloud storage models and communication API's, Data analytics: predictive maintenance, anomaly detection, process optimization, Role of AI/ML in IIOT.

Unit IV- IIOT SECURITY AND STANDARDS - (9 Hours)

Security challenges in IIOT: device security, data privacy, network security, Threats: spoofing, denial of service, malware in industrial environments, Security mechanisms: authentication, encryption, blockchain for IIOT, Industrial standards and regulatory compliance (IEC 62443, ISO 27001, NIST guidelines), Resilience and safety in IIOT systems.

Unit V- APPLICATIONS AND CASE STUDIES - (9 Hours)

Smart manufacturing and Industry 4.0, Predictive maintenance and digital twins, Smart energy management and smart grids, IIOT in logistics and supply chain management, Future trends: 5G, AI-driven IIOT, Cyber-physical systems, Case studies of IIOT communication in industries.

Learning Resources

Text Books:

1. Internet of Things: A Hands-On Approach Arshdeep Bhaga, Vijay Madisetti VPT – Paperback 2015 978- 0996025515 628/- 2
2. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things David Hanes, Gonzalo Salgueiro, Patrick Grossetete Cisco Press – Paperback – 16 Aug 2017 978-1-58714-456- 1 599/-
3. Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications Daniel Minoli Willy Publication s - 2013 978-1-118- 47347-4, 466/-
4. *Industrial Internet of Things: Cybermanufacturing Systems* – Sabina Jeschke et al.
5. *Architecting the Industrial Internet* – M. Jamshidi
6. *Designing Connected Products: UX for the Consumer Internet of Things* – Claire Rowland et al.

Reference Books:

1. Smart Internet of things projects Agus Kurniawan Packt - Sep 2016 978-1- 78646- 651-8 2 The Internet of Things Key Olivier Willy Publication 2nd Edition 978-
2. Applications and protocols Hersent s 119- 99435-0, 3 The Internet of Things Connecting Objects to the Web Hakima Chaouchi, Willy Publications 978-1- 84821- 140-7

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet of Things**		
PCC-552-IOT - Embedded Technology and IOT		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 04 Hours/Week	04	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Embedded System and analog circuits

Course Objectives: The course aims -

1. To give insight to various platforms needed for Embedded Technologies and IoT.
2. To expose students to the usage of protocol standardization in Embedded Technologies and It's selection to various applications.
3. To Understand the fundamental of sensors and actuators along with the basic concepts of an IoT and how to design IoT based applications.

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

- CO1: Understand various Embedded platforms and IoT platforms.
- CO2: Comprehend the operation of different buses and protocols.
- CO3: Interpret IoT architecture design aspects and its analyze concepts.
- CO4: Develop design skills in industrial IoT.
- CO5: Provide suitable solution for specific application and illustrate the technologies of IoT using suitable case studies.

Course Contents

Unit I - ARM, Raspberry Pi Microcontroller - (9 Hours)

Basics of Raspberry Pi **(**RPi) board, Features and architecture, pin configurations, Installing OS on RPi, connecting to network, Programming languages with examples, Various interfaces e.g. I2C, UART, SPI, CAN. Node MCU ESP8266 Pin configuration, Station, AP, ST-AP modes, Node MCU as web server, posting sensor data to gateway.

Unit II - Buses and Protocols- (9 Hours)

CAN Bus: Features and applications, CAN Frame, sequence of transmitting and receiving data on CAN Bus. Ethernet and USB Bus: Features and applications. Protocols: PHY/MAC Layer (3GPP MTC, IEEE 802.11, IEEE 802.15), Bluetooth Low Energy, Zigbee Smart Energy, Network Layer-IPv4, IPv6, 6LoWPAN, Transport Layer (TCP, MPTCP, UDP) Session Layer HTTP, CoAP, XMPP, AMQP, MQTT

Unit III - IoT Fundamentals- (9 Hours)

IoT Architecture and Design Concepts: IoT – An architectural overview, Design Principles and capabilities, M2M & IOT Technology Fundamentals- End Devices and gateways, Local and wide area networking, Challenges Associated with IoT, Cloud Platforms for IoT. Sensors: Different types of sensors and Actuators, Working, Networking Basics, RFID Principals and components, Wireless Sensor Networks, Physical Design of an IoT, Logical design of IoT Communication Models, Communication API's, Concept of IoE, Difference between IoT and IoE.

Unit IV- Industrial IoT- (9 Hours)

Introduction, Key Industrial IOT (IIOT) technologies, Catalysts, and precursors of IIOT, Innovation and the IIOT, Applications of IIOT Examples: Healthcare, Oil and Gas Industry, Logistics and the Industrial Internet, Retail applications, IoT innovations and design methodologies.

Unit V- IoT Applications- (9 Hours)

Applications: Smart Environment: Forest Fire Detection, Air Pollution, Smart Cities: Parking, Structural Health, Noise Urban maps, Smart Metering: Smart Grid, Tank level, Photovoltaic Installations, Health: Fall Detection, Medical Fridges, Sportsmen Care, Patients Surveillance.

Learning Resources

Text Books:

1. Olivier Hersent, David Boswarthick, and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2nd Edition, Wiley Publications.
2. Arshdeep Bhaga and Vijay Madisetti, "Internet of Things: A Hands-On Approach", Orient Black swan Private Limited - New Delhi; First Edition (1 January 2015).
3. Simon Monk, "Programming Raspberry Pi", McGraw Hill TAB; 2nd edition (16 November 2015).

Reference Books:

1. Andrew Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide – Designing and Optimizing System Software", ELSEVIER
2. Dr. Ovidiu Vermes an, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series
3. Rajesh Singh, "Internet of Things with Raspberry Pi and Arduino", CRC Press 2020.

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet of Things**		
PCC-553- IOT - Web Programming and Java		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 04 Hours/Week	04	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Computer Networks, Operating Systems

Course Objectives: The course aims to:

1. To build foundations in Java and object-oriented design for reliable IoT back-end services.
2. To develop Node.js solutions using events, buffers/streams, file I/O, and timers for device data handling.
3. To design and expose Web Services (SOAP vs REST) and implement Express.js based REST APIs for IoT (e.g., device registration & telemetry).
4. To manage IoT data lifecycles (ingest → store → visualize) and design dashboards with modern frontend practices.
5. To apply secure, testable, and maintainable patterns across the stack.

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

- CO1: Apply Java language features (variables, data types, control flow, classes, constructors, interfaces, memory concepts) to build modular components
- CO2: Develop Node.js applications using the event loop, Event Emitter, buffers/streams, file handling, and timers for IoT workloads
- CO3: Compare SOAP vs REST and implement RESTful services with Express.js, including device registration and telemetry endpoints
- CO4: Implement data management pipelines and create data visualizations/dashboards (Angular 4 basics + charting).
- CO5: Integrate and evaluate a full-stack IoT web system (Java + Node + REST + frontend) with attention to security, testing, and performance

Course Contents

Unit I- Java Programming Foundations for IoT Backends (9 Hours)

Java platform overview; JDK/JVM basics, memory model (stack/heap/GC overview), class loading (high level). Language essentials: variables, data types, operators, control statements (if/switch/loops). OOP fundamentals: classes, objects, constructors, method overloading/overriding, this, static. Interfaces & abstraction; basic packages/access modifiers; intro to collections & generics (list/map). Memory concepts: immutability basics, object lifetime, references vs values. Hands-on: Build a Java module for sensor reading validation & simple in-memory repository.

Unit II - Node.js Fundamentals: Events, Buffers, Files, Timers - (7 Hours)

Introduction to Node.js: runtime, npm, module system (Commons/ESM), blocking vs non-blocking I/O. Event Handling: Event loop, Event Emitter, custom events, callback vs Promise vs async/await. Buffer & String Handling: Buffer API, encoding (UTF-8/base64), binary vs text; working with streams. File Handling: fs (sync/async), streams (readable, writable, pipeline), directory ops, watchers. Timers: set Timeout, set Interval, set Immediate, scheduling caveats and drift. Hands-on: Build a Node service that ingests sample device files, parses buffers, raises events, and persists output.

Unit III - Web Services: SOAP vs REST; Express.js Essentials - (8 Hours)

Web Services landscape: SOAP fundamentals (WSDL, envelope), REST principles (resources, verbs, status codes). SOAP vs REST comparison: coupling, tooling, payload formats, typical IoT fit. Express.js: routing, middleware, query/path params, request validation, error handling. Designing REST APIs for IoT: Device registration (provisioning, keys/tokens), Device status & configuration endpoints, Telemetry ingestion (JSON), pagination & filtering, Versioning, idempotency, rate limiting (concepts). Serialization: JSON/CSV basics; brief on CBOR/Protobuf (awareness). Testing & Docs: Postman/Thunder Client, Open API (Swagger) annotations/tools.

Unit IV- Data Management, Visualization & Dashboard Design - (7 Hours)

Data management: schema choices (events vs state), simple SQL/NoSQL options (awareness), indexing basics. Server-side data ops (Node/Java): validation, transformation, ETL mini-patterns. Data Visualization: principles (clarity, scales, aggregation), charts for telemetry (line, area, bar). Dashboard Design: layout, widgets, alerts, auto-refresh, access control basics. Basics of Angular 4: project structure (CLI), components, templates, data binding, services, HTTP client, routing. Integrating charts (e.g., Chart.js/Google Charts—concepts) and calling REST APIs.

Unit V- Integration, Security Basics, and Performance - (7 Hours)

Security basics for web/IoT: HTTPS/TLS (awareness), API keys/JWT (concepts), CORS, input validation, OWASP top-10 (intro). Logging & monitoring (concepts): structured logs, simple metrics; error handling strategies. Performance: async best practices, avoiding blocking calls, pagination, simple load testing (Postman/JMeter basics)

Learning Resources

Text Books:

1. **Herbert Schildt**, *Java: The Complete Reference* Eleventh **edition**. McGraw-Hill Education
2. **Ethan Brown**, *Web Development with Node & Express*, O'Reilly Media, 2014.
3. **Shyam Seshadri**, *Angular: Up and Running* (editions covering Angular 4+ basics).

Reference Books:

1. Kyle Simpson, *You Don't Know JS Yet*, 2nd edition, Premedia launch LLC (print); GetiPub/e-publishers (digital) 2020

2. Leonard Richardson & Mike Amundsen, *RESTful Web APIs*, 1st edition, O'Reilly Media, 2013

3. Martin Kleppmann, *Designing Data-Intensive Applications*, 1st edition, O'Reilly Media, 2017

4. Douglas Crockford, *JavaScript: The Good Parts* 1st edition, O'Reilly Media, 2008

5. Official Docs: Node.js, Express.js, Angular (v4), Open API/Swagger, Postman.

SWAYAM/MOOC/eBooks:

1. **Programming In Java By Prof. Debasis Samanta, IIT Kharagpur**
https://onlinecourses.nptel.ac.in/noc22_cs47/preview

2. **Web Technology By Dr. Ashutosh Kumar Bhatt,Uttarakhand Open University, Haldwani**
https://onlinecourses.swayam2.ac.in/nou24_cs09/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet of Things**		
PCC-554-IOT- IoT Lab Practice –II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 04 Hours/Week	02	**Term work**: 25 Marks **Oral**: 25 Marks

Prerequisite Courses: Internet of Things sensors platforms, PLC, Cloud platform, ML algorithms, Blockchain Technology.

Course Objectives: The course aims -

1. To understand Industrial Internet of Things sensor and its interfacing.
2. To Understand IIOT Security application.
3. To understand industrial application of IoT

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

CO1: Understand Industrial Internet of Things sensor and its interfacing.
CO2: Understand the Data Acquisition and Processing techniques.
CO3: Understand IIOT Security application.
CO4: Understand cloud industrial application.
CO5: Understand ML industrial application.

Lab Practical

Guidelines:

1. IoT Lab Practice-II Experiments are based on Industrial Internet of Things Programme core courses.
2. Use suitable opensource available software.

Part A: Embedded Technology and IOT (Any 2)

1. IoT based stepper motor/ DC motor control using Raspberry-Pi.
2. To use MQTT/ CoAP protocol and send sensor data to cloud using Raspberry-Pi/ ESP8266.
3. To prepare IoT based small project implementation on the topics based on small problem statements of the fields like smart home (Home Automation) etc. This project can be built on any IoT simulation platform like Tinker cad, Coola etc

Part B: Smart Healthcare system for IOT (Any 2)

1. To develop IoT based heart rate and temperature monitoring system for Patient . .
2. To develop IoT based smart medication reminder system for Patient .
3. To utilize MQTT protocol and send bio-sensor data to cloud using Raspberry-Pi/ ESP8266.
4. To prepare IoT based Patient-Room Environment Monitoring (Temp, Humidity, Air Quality. This project can be built on any IoT simulation platform like Tinker cad, Cooja etc.

Part C: 5G and IoT Integration (Any 2)

1. Design and simulation of a 5G-enabled smart city framework
2. Protocol performance comparison for industrial 5G-IoT
3. Secure authentication for NB-IoT devices in 5G networks
4. Machine Learning-based traffic management in 5G-IoT edge networks

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet Of Things**		
PEC-571A-IOT - Cyber Security (Elective II)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

- Fundamentals of Computer Network
- Basic of Network Security

Course Objectives: The course aims -

1. To understand various types of cyber-attacks and cyber-crimes.
2. To learn threats and risks within context of the cyber security.
3. To have an overview of the cyber laws & concepts of cyber forensics.
4. To study the defensive techniques against these attacks.
5. To understand various cyber security privacy issues.

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

- CO1: Analyze and evaluate the cyber security needs of an organization.
- CO2: Understand Cyber Security Regulations and Roles of International Law and concept of forensics analysis.
- CO3: Analyze the security issues in various devices.
- CO4: Design and develop a security architecture for an organization.
- CO5: Understand fundamental concepts of data privacy attacks.

Course Contents

Unit I - Introduction to Cyber Security (8 Hours)

Basic Cyber Security Concepts, layers of security, Vulnerability, threat, Harmful acts, Internet Governance – Challenges and Constraints, Computer Criminals, CIA Triad, Assets and Threat, motive of attackers, active attacks, passive attacks, Software attacks, hardware attacks, Cyber Threats-Cyber Warfare, Cyber Crime, Cyber terrorism, Cyber Espionage, etc., Comprehensive Cyber Security Policy.

Unit II – Cryptographic Fundamentals for IoT Security Engineering - (8 Hours)

Cryptography and its role in securing the IoT, Types and uses of cryptographic primitives in the IoT, Encryption and decryption- Symmetric encryption , RC5, Diffie-Hellman key exchange algorithm, RSA algorithm, Elgamal Arithmetic, Elliptic Curve Cryptography, Message Digest and Cryptographic Hash Functions, MD5 and SHA-1,Random number generation, Cipher suites, Examining cryptographic controls for IoT protocols- Cryptographic controls built into IoT communication protocols(ZigBee, Bluetooth, Near field communication (NFC)), Cryptographic controls built into IoT messaging protocols – MQTT, CoAP, DDS, REST, Future directions of the IoT and cryptography.

Unit III – Identity and Access Management Solutions for the IoT - (8 Hours)

An introduction to identity and access management for the IoT- The identity lifecycle, Establish naming conventions and uniqueness requirements, Secure bootstrap, Credential and attribute provisioning, Account monitoring and control, Account/credential deactivation/deletion, Authentication credentials- Passwords, Symmetric keys, Certificates X.509, IEEE 1609.2, Biometrics, Digital Signature. IoT IAM infrastructure - 802.1x, PKI for the IoT, Authorization and access control. IP Security: IPv6 and IPSec, Web Security: SSL, HTTPS, Mail Security: PGP, S/MIME. Firewall.

Unit IV- Attacks and Countermeasures - (7 Hours)

Phishing, Password Cracking, Key-loggers and Spywares, Types of Viruses, Worms, DoS and DDoS, SQL injection, Buffer Overflow, Spyware, Adware and Ransomware. Antivirus and other security measures Intrusion Detection System: IDS fundamentals, Different types of IDS. Intrusion Prevention.

Unit V-The IOT Security Lifecycle & Privacy Issue- (8 Hours)

The secure IoT system implementation lifecycle, Implementation and integration - IoT security CONOPS document, Network and security integration, System security verification and validation (V&V), Security training, Secure configurations, Operations and maintenance - Managing identities, roles, and attributes, Security monitoring, Penetration testing, Compliance monitoring, Asset and configuration management, Incident management,

Privacy Issues: Basic Data Privacy Concepts: Fundamental Concepts, Data Privacy Attacks, Data linking and profiling, privacy policies and their specifications, privacy policy languages, privacy in different domains- medical, financial, etc.

Learning Resources

Text Books:

1. Nina Godbole, Sunit Belapure, Cyber Security- Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley India Pvt.Ltd, ISBN- 978-81-265-2179-1
2. B.B. Gupta, D.P. Agrawal, Hoaxing Wang, Computer and Cyber Security: Principles, Algorithm, Applications, and Perspectives, CRC Press, ISBN 9780815371335,2018.
3. Practical Internet of Things Security, Brian Russell, Drew Van Duren, PACKT Publishing.
4. Parikshit N. Mahale, Poonam N. Raikar, —Identity management for internet of things, River publications.

Reference Books:

1. Cyber Security Essentials, James Graham, Richard Howard and Ryan Otson, CRC Press.
2. Introduction to Cyber Security, Schwan-Hwa(john) Wu, J. David Irwin, CRC Press T&F Group.
3. Berouz Forouzan, Cryptography and Network Security, TMH, 2 edition, ISBN-978-00-707-0208-0.
4. Fei Hu, —Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations —, ISBN: 9781498723183, CRC Press, 2016.

Savitribai Phule Pune University Master of Engineering (2025 Course) – Internet of Things		
PEC-571B-IOT -Energy and power management for IOT Devices (Elective II)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Electronics, Networks, and IoT basics

Course Objectives: The course aims -

1. To introduce the fundamentals of energy requirements, consumption patterns, and challenges in IoT devices and networks.
2. To familiarize students with various power sources, batteries, supercapacitors, and energy harvesting techniques suitable for IoT applications.
3. To develop an understanding of low-power hardware and software design techniques along with energy-efficient communication protocols.
4. To enable students to design and implement effective power and energy management strategies for IoT systems.

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

- CO1: Explain the energy requirements, consumption patterns, and challenges in IoT devices and networks.
- CO2: Analyse different power sources, batteries, supercapacitors, and energy harvesting methods suitable for IoT applications.
- CO3: Apply hardware and software-level low-power design techniques and evaluate energy-efficient communication protocols for IoT systems.
- CO4: Design and implement power management strategies, including task scheduling, synchronization, and routing in IoT environments.
- CO5: Explore and assess advanced trends such as AI-driven energy optimization, green IoT, and sustainable battery-less IoT solutions in real-world applications.

Course Contents

Unit I - Introduction to IoT Energy & Power Requirements (8 Hours)

IoT device architecture, components, and application, Power consumption in IoT: active, idle, sleep modes Energy challenges in IoT networks. Metrics for energy efficiency (energy per operation, duty cycle, battery life)
Case studies: power-hungry vs. low-power IoT devices

Unit II - Power Sources for IoT Devices (8 Hours)

Primary & secondary batteries (Li-ion, NiMH, coin cells, thin-film batteries) , Battery performance parameters: lifetime, capacity, cycles. Supercapacitors & hybrid storage systems. Energy harvesting methods: Solar, Piezoelectric, Thermoelectric, RF harvesting. Comparative analysis of power sources for IoT

Unit III - Low Power Design Techniques (8 Hours)

Hardware-level optimization: low-power MCUs, sensors, analog front-ends. Software-level techniques: duty cycling, DVFS, adaptive sensing. Power-aware communication protocols: Zigbee, BLE, Lora WAN, NB-IOT. Data transmission optimization: aggregation, compression, edge computing. Case study: Energy efficiency in wireless sensor networks (WSN)

Unit IV- Energy Management Systems for IoT (8 Hours)

Power Management ICs (PMICs), DC-DC converters, regulators. Energy-aware task scheduling & resource allocation. Sleep/wake-up strategies & synchronization in IoT nodes. Energy-aware routing protocols in IoT networks. Middleware and OS-level support (Tinos, Contiki, RIOT)

Unit V- Future Trends and Applications (8 Hours)

AI/ML for energy optimization in IoT. Green IoT and sustainable energy models. Self-powered & battery-less IoT devices. Ultra-low-power wide-area networks (LPWAN). Real-world case studies: smart homes, healthcare, agriculture, industry.

Learning Resources

Text Books:

1. **Daniel Minoli** – *"Internet of Things: Energy Management in IoT Devices"* – Wiley, 2022.
2. **C.S. Raghavendra, Krishna M. Sivalingam, Taieb Znati** – *"Wireless Sensor Networks"* – Springer, 2010.
3. **Anna Ha´c** – *"Wireless Sensor Network Designs"* – Wiley, 2003.
4. **Sabrie Soloman** – *"Sensors Handbook"* – McGraw-Hill, 2010.
5. **Adel S. Sedra, Kenneth C. Smith** – *"Microelectronic Circuits"* – Oxford University Press, 2014.

Reference Books:

1. **Kazem Sohrab, Daniel Minoli, Taieb Znati** – "Wireless Sensor Networks: Technology, Protocols, and Applications" – Wiley, 2007.
2. **Anna Hà's** – "Wireless Sensor Network Designs" – Wiley, 2003.
3. **Omgba Essama Armel** – "Energy Harvesting for Autonomous Systems" – Artech House, 2011.
4. **Sabrie Soloman** – "Sensors Handbook" – McGraw-Hill, 2010.
5. **Mani Srivastava, Deborah Estrin, David Culler (Editors)** – "Wireless Sensor Networks: An Overview" – IEEE Proceedings, 2004.
6. **Sudip Misra, Ananda up Mukherjee, Arijit Roy** – "Introduction to Wireless and Mobile Systems" – McGraw Hill, 2012.
7. **H. Karl, A. Willig** – "Protocols and Architectures for Wireless Sensor Networks" – Wiley, 2005.
8. Design for Internet of Things – Prof. Prabhakar T.V., IISc Bangalore (NPTEL) https://onlinecourses.nptel.ac.in/noc21_ee85/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet Of Things**		
PEC-571 C- IOT Machine Learning (Elective II)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

Engineering Mathematics (Linear Algebra, Probability & Statistics, Calculus), Digital signal processing, Data Structures and Algorithms

Course Objectives: The course aims to:

1. Introduce fundamental Machine Learning concepts and their applications in real-world problems.
2. Implement regression and classification models to solve engineering problems
3. Apply clustering and dimensionality reduction techniques to unlabeled data.
4. Optimize datasets through preprocessing and feature selection for Machine Learning pipelines.

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

CO1: Compare Machine Learning paradigms for real time applications
CO2: Design regression models for predictive tasks and classification models for signal/label prediction.
CO3: Develop clustering models and PCA-based solutions for defect detection or customer segmentation.
CO4: Construct feature engineering pipelines to improve model performance in IoT/telecom datasets.
CO5: Implement ensemble techniques to enhance accuracy in IC testing or power grid stability.

Course Contents

Unit I - Introduction to Machine Learning - (7 Hours)

Introduction, Definition and motivation, History and evolution of Machine learning, types: Supervised, Unsupervised, Semi-supervised, Reinforcement, Machine Learning Models: Geometric, Probabilistic, Logical, and Parametric. Non-parametric, Applications of Machine Learning in Signal processing, speech recognition, image processing, Wireless communications.

Unit II - Supervised Machine Learning - (7 Hours)

Introduction to Supervised Learning, Types of Supervised Problems, Regression Models: Linear Regression, Types of Linear Regression, cost function, gradient descent of linear regression, Evaluation Metrics for Linear Regression.
Classification Models: Logistic Naive Bayes algorithm KNN algorithm Support Vector Machine (SVM).

Unit III - Unsupervised Machine Learning - (7 Hours)

Introduction, Types of Unsupervised Learning: Clustering, Association Rule Learning, Dimensionality Reduction, K-means Clustering algorithm, Evaluation: Elbow method, Silhouette score, Density-Based Methods, Dimensionality Reduction Techniques, Principal Component Analysis (PCA), Apriorism

Unit IV- Feature Engineering- (7 Hours)

Importance of feature engineering in Machine Learning pipeline, handling missing values, outliers, encoding: Label, One-Hot, Ordinal, Target Scaling: Min-Max, Standardization, Normalization, Feature selection: Filter (Chi-square), Wrapper (RFE), Embedded (Lasso)

Unit V- Ensemble Learning and Model Evaluation- (7Hours)

Introduction to Ensembles, Need of Ensemble Learning, Basic Ensemble Learning Techniques: Voting (Hard/Soft), Advanced Ensemble Learning Techniques: Bagging (Random Forest), Boosting (AdaBoost, XGBoost), Stacking, Cross-validation: Hold-out, K-Fold, LOOCV, Model comparison using t-test, McNemar's test, Hyperparameter tuning (Grid Search, Random Search)

Learning Resources

Text Books:

1. Ethem Alpaydin, "Introduction to Machine Learning", Publisher: The MIT Press,2014
2. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, Edition 2012

Reference Books:

1. Ian H Witten, Eibe Frank, Mark A Hall, "Data Mining, Practical Machine Learning Tools and Techniques", Elsevier, 3rd Edition
2. Jiawei Han, Micheline Kamber, and Jian Pie, "Data Mining: Concepts and Techniques", Elsevier Publishers Third Edition, ISBN: 9780123814791, 9780123814807
3. Shalev-Shwartz, Shai, and Shai Ben-David, "Understanding machine learning: From theory to algorithms", Cambridge university press, 2014
4. McKinney, "Python for Data Analysis O' Reilly media, ISBN : 978-1-449- 31979-3

MOOC Courses:

1. Introduction to Machine Learning(IIT kharagpur) : https://nptel.ac.in/courses/106105152
2. Introduction to Machine Learning (IIT Madras): https://onlinecourses.nptel.ac.in/noc22_cs29/prevew
3. Machine Learning A-Z™: AI, Python & R + ChatGPT Bonus [2025] https://www.udemy.com/course/machinelearning/
4. Machine Learning and Deep Learning A-Z: Hands-On Python https://www.udemy.com/course/machine-learning-and-deep-learning-a-z-hands-on-python/

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet of Things**		
PEC-571D-IOT - Edge and Fog computing (Elective II)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Cloud Computing, Embedded System and IoT

Course Objectives: The course aims -

1. To explore the fundamentals and basic concepts of Edge and Fog Computing.
2. To design and integrate different services of Edge and Fog computing with IoT.
3. To analyze and summarize different applications of Edge and Fog computing across multiple domains.

Course Outcomes: After completion of this course, the student will be able to:

CO1: Explore and explain basic concepts of Edge and Fog Computing (EFC).

CO2: Comprehend the different protocols of EFC.

CO3: Interpret IoT architecture with EFC concepts.

CO4: Develop and design services of Edge and Fog computing with IoT.

CO5: Design a case study for real time application using EFC in different domain.

Course Contents

Unit I – Introduction to Edge and Fog Computing (EFC) - (8 Hours)

Overview of Cloud, Edge, and Fog Computing, Need for Edge and Fog in IoT with real-time applications, Key differences: Edge vs Fog vs Cloud, Benefits, limitations, and challenges, (Reference architecture: OpenFog architecture (optional))

Unit II – Protocols and communication models in EFC- (8 Hours)

Communication models in Edge and Fog systems, IoT-Fog-Cloud integration protocols (MQTT, CoAP, AMQP, HTTP/REST), Data aggregation and pre-processing at the edge, Latency, bandwidth, and quality of service (QoS) considerations, Security and privacy in data transmission

Unit III - IoT Architectures and its integration with EFC- (6 Hours)

IoT architecture and layers, Integration of Edge and Fog nodes in IoT, Sensor data collection and processing at the edge, Use of edge analytics and fog orchestration.

Unit IV- Service Design and Development in EFC- (7 Hours)

Designing services in EFC environment, Task offloading and resource allocation, Middleware platforms (e.g., EdgeX Foundry, KubeEdge, iFogSim), Fog and Edge Computing as a Service (FCaaS, ECaaS), Application deployment and testing using simulation tools.

Unit V- Applications and Case studies of EFC- (9 Hours)

Real-time applications in healthcare, agriculture, transportation, and smart homes, designing an end-to-end use case with EFC integration, Performance evaluation metrics: latency, energy, cost.
Case studies: Smart city, Smart grid and Industrial IoT. (Any 2)
(Case study development and presentation: Recent trends and research directions in Edge and Fog computing)

Learning Resources

Text Books:

1. Fog and Edge Computing: Principles and Paradigms – Rajkumar Buyya, Satish Narayana Srirama, Wiley, 2019.
2. Fog Computing in the Internet of Things – Amir M. Rahmani et al., Springer, 2018.

Reference Books:

1. **Fog Computing: A Taxonomy, Survey and Future Directions -** Redowan Mahmud, Ramamohanarao Kotagiri, Rajkumar Buyya, Elsevier, 2016.
2. **Intelligent Internet of Things: From Device to Fog and Cloud -** Farshad Firouzi, Bahar Farahani, Markus Weinberger, Gabriel DePace, Fereidoon Shams Aliee, Springer, 2020.
3. **All One Needs to Know about Fog Computing and Related Edge Computing Paradigms: A Complete Survey -** Ashkan Yousefpour, Caleb Fung, Tam Nguyen, Krishna Kadiyala, Fatemeh Jalali, Amirreza Niakanlahiji, Jian Kong, Jason P. Jue, Elsevier, 2018.

Online Resources:

- OpenFog Reference Architecture (openfogconsortium.org)
- NPTEL and Coursera courses on Edge/Fog/IoT
  https://onlinecourses.nptel.ac.in/noc24_cs66/preview
  https://onlinecourses.nptel.ac.in/noc25_cs75/preview

https://www.coursera.org/specializations/security-at-the-edge

- Developer resources: EdgeX Foundry, iFogSim tutorials
  https://docs.edgexfoundry.org/2.3/getting-started
  https://training.linuxfoundation.org/express-learning/creating-edge-iot-solutions-with-edgex-foundry-lfel1003/
  https://github.com/Cloudslab/iFogSim1

Savitribai Phule Pune University Master of Engineering (2025 Course) – Internet of Things		
PCC-572A-IOT - 5G and IOT Integration (Elective III)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 04 Hours/Week	04	**CCE:** 50 Marks **End-Semester:** 50 Marks

Prerequisite Courses: Internet of Things Basics, Embedded System, and 5G Basics

Course Objectives: The course aims to

1. To understand the Fundamentals of 5G Technology.
2. To explore IoT Concepts and Protocols.
3. To analyze the Synergy Between 5G and IoT.
4. To design and Develop 5G-Enabled IoT Systems.
5. To address Security and Privacy Challenges.

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

CO1: Provide a comprehensive understanding of 5G technologies and their suitability for large-scale IoT applications.
CO2: Explore architectural frameworks and enabling technologies for integrated 5G-IoT systems.
CO3: Analyze and critique key standards, protocols, and deployments.
CO4: Investigate cutting-edge application and security aspects of 5G-enabled IoT systems.
CO5: Encourage independent research and project-based learning in emerging 5G-IoT domains.

Course Contents

Unit I - Evolution and Convergence of 5G and IoT - (9 Hours)

Evolution of mobile networks from 1G to 5G, Technical overview of 5G: Use cases, capabilities, and KPIs, IoT ecosystem and architecture: Perception, network, application layers, Role of 5G in IoT: mMTC, URLLC, and eMBB, Convergence trends and vision of hyper-connected ecosystems.

Unit II - 5G Network Architecture and Enablers for IoT - (9 Hours)

5G NR architecture and protocol stack, Service-Based Architecture (SBA) and 5G Core, Network slicing for IoT verticals, Mobile Edge Computing (MEC) and Multi-access Edge Computing, Role of Massive MIMO, Beamforming, and mm Wave in IoT support, Software Defined Networking (SDN) and Network Function Virtualization (NFV).

Unit III - Protocols, Standards, and Interoperability in 5G-IoT - (9 Hours)

3GPP standardization for IoT: NB-IoT, LTE-M, Rel-16 and beyond, IoT communication protocols over 5G: MQTT, CoAP, AMQP, DDS, 6LoWPAN, Interoperability issues in heterogeneous IoT-5G systems, Time-Sensitive Networking (TSN) for Industrial IoT over 5G, Data management and cloud-native architectures.

Unit IV- Applications, Case Studies, and Performance Evaluation - (9 Hours)

Smart cities, smart grids, precision agriculture, digital health, and autonomous systems, V2X (Vehicle-to-Everything) and Intelligent Transportation Systems, Industrial IoT (IIOT) and automation with 5G, Performance metrics: Latency, throughput, energy efficiency, reliability, Case studies: 5G-IoT deployments in Europe, Asia, and North America, Use of AI/ML in 5G-IoT for traffic prediction, anomaly detection, and optimization

Unit V- Challenges, Security, and Future Research Directions - (9 Hours)

Security threats in 5G-enabled IoT: device, network, and data layers, Lightweight cryptography and identity management for constrained IoT, Privacy, ethical, and regulatory concerns, Open challenges: Mobility, scalability, spectrum, and backward compatibility, Research directions: 6G, digital twins, AI-native networks, Blockchain for IoT.

Learning Resources

Text Books:

1. Erik Dahlman, Stefan Parkvall, Johan Skold "5G NR: The Next Generation Wireless Access Technology", Elsevier Academic Press.
2. Raj Kamal "Internet of Things: Architecture and Design Principles" McGraw Hill Education (India) Private Limited.
3. Afif Osseiran, Jose F. Monserrat "5G and Beyond: Fundamentals and Standards" Cambridge Press.

Other Key References:

1. Dr. Ovidiu Vermes an, Dr. Peter Friess, “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers Series
2. 3GPP Technical Reports and Specifications (www.3gpp.org)
3. IEEE Journals and Conferences on IoT and 5G
4. Whitepapers from Ericsson, Huawei, Qualcomm, Intel on 5G-IoT
5. NIST and ETSI reports on IoT standardization and architecture

Laboratory Assignments:

- Design and simulation of a 5G-enabled smart city framework
- Protocol performance comparison for industrial 5G-IoT
- Secure authentication for NB-IoT devices in 5G networks
- Latency optimization in 5G URLLC scenarios for autonomous vehicles
- Machine Learning-based traffic management in 5G-IoT edge networks

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet of Things**		
PCC-572B- IOT - IoT Protocols and Standards (Elective III)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Embedded Systems, VLSI Design, Digital Circuits, Microcontrollers

Course Objectives: The course aims -

1. To provide knowledge of IoT protocol stack and standardization efforts.
2. To understand IoT communication requirements across physical, network, and application layers.
3. To enable learners to design and evaluate IoT solutions using standard protocols and frameworks

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

- CO1: Explain IoT protocol stack and relevant standards.
- CO2: Analyse physical, data link, and network layer protocols for IoT communication.
- CO3: Apply application layer protocols (MQTT, CoAP, AMQP, etc.) in IoT systems.
- CO4: Evaluate interoperability, scalability, and security aspects of IoT standards.
- CO5: Design IoT applications using appropriate protocols and case studies.

Course Contents

Unit I - Introduction to IoT Protocols and Standards - (8 Hours)

Overview of IoT protocol stack; need for standardization; role of ITU, IETF, IEEE, and 3GPP in IoT; comparison of IoT and traditional internet protocols; taxonomy of IoT communication standards

Unit II - Physical and Data Link Layer Protocols - (8 Hours)

Physical layer standards for IoT – IEEE 802.11 (Wi-Fi), IEEE 802.15.4 (ZigBee, 6LoWPAN), Lora WAN, NB-IoT; MAC layer protocols; channel access methods; low-power wide area network (LPWAN) standards.

Unit III - **Network and Transport Layer Protocols** - (8 Hours)

IPv4/IPv6 for IoT, 6LoWPAN adaptation, RPL routing protocol; transport protocols – TCP, UDP, and MPTCP in IoT; cross-layer design issues; addressing and scalability challenges.

Unit IV Application Layer Protocols and Interoperability - (9 Hours)

Application protocols: MQTT, CoAP, AMQP, XMPP, DDS; REST vs. SOAP for IoT; interoperability challenges and solutions; protocol gateways and middleware frameworks; case studies of protocol implementation in smart city/healthcare IoT.

Unit V- Security, Standards, and Case Studies - (9 Hours)

IoT security standards – TLS/DTLS, IPSec, lightweight cryptography; authentication and identity management protocols; overview of oneM2M, AllJoyn, OCF, and industrial IoT standards; case studies on protocol selection and deployment in smart energy, logistics, and healthcare IoT.

Learning Resources:

Text Books :

1. Arshdeep Bahga and Vijay Madisetti, *Internet of Things: A Hands-On Approach*, Orient Blackswan.
2. Olivier Hersent, David Boswarthick, and Omar Elloumi, *The Internet of Things: Applications and Protocols*, Wiley.
3. 3.Raj Kamal, *Internet of Things: Architecture and Design Principles*, McGraw Hill

Reference Books:

1. Adrian McEwen and Hakim Cassimally, *Designing the Internet of Things*, Wiley.
2. Charalampos Doukas, *Building Internet of Things with the Arduino*, CreateSpace.
3. Dr. Ovidiu Vermesan, Dr. Peter Friess, *Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems*, River Publishers.

Online Resources- MOOC / NPTEL:

1. NPTEL Course "IoT Protocols and Architecture" https://nptel.ac.in/courses/106/105/106105220/
2. NPTEL Course "IoT Systems and Applications" https://nptel.ac.in/courses/106/105/106105195/

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet of Things**		
PEC-572C- IOT - Cloud Architecture Protocols (Elective III)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To define core cloud architecture principles using standardized models (NIST, SPI).
2. To analyze network protocol mechanics, including encapsulation systems and data centre topologies.
3. To evaluate security frameworks using cryptographic protocols and identity management algebras.

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

CO1: Classify cloud service/deployment models using NIST taxonomies and deconstruct virtualization architectures.

CO2: Analyze encapsulation protocols and data center fabrics using routing algebras and congestion control formalisms.

CO3: Analyze the components of a virtualized data center and review the performance of Data archiving solutions.

CO4: Implement /identity cryptographic protocols via state-machine models and Zero Trust policy algebras.

CO5: Quantify system resilience using queueing theory, failure distributions and resource optimization heuristics.

Course Contents

Unit I - Cloud Ontology & Architectural Frameworks - (8 Hours)

Foundational Models: NIST essential characteristics, SPI service model taxonomy, resource abstraction layers. Deployment Topologies: Public, Private and Hybrid structural patterns, community cloud governance frameworks. Virtualization Theory: Hypervisor architectures (Bare-metal/Hosted), container isolation formalisms, docker basics and architecture.

Unit II - Network Virtualization & Protocol Architectures - (8 Hours)

Encapsulation Systems: VXLAN/Geneve header structures, NVGRE protocol mechanics, virtual switching paradigms. Data Center Fabrics: BGP-EVPN control plane theory, Clos topology mathematics, spine-leaf routing algebras. Transport Layer Theory: TCP congestion control formalisms, QoS traffic shaping models, packet scheduling algorithms.

Unit III - Storage Networks - (8 Hours)

Storage network design considerations: NAS and FC SANs, hybrid storage networking technologies (iSCSI, FCIP, FCOE), design for storage virtualization in cloud computing, host system design considerations. Replications in NAS and SAN environments. Data archiving solutions, analyzing

compliance and archiving design considerations.

Unit IV- Security Protocols & Cryptographic Frameworks - (7 Hours)

Identity Systems: SAML 2.0 assertion flows, OAuth 2.0 grant type formalisms, RBAC/ABAC policy algebras. Cryptographic Systems: TLS 1.3 handshake state machine, AES-GCM mode operations, PKI trust hierarchies. Network Security Models: Zero Trust formal architectures, IPsec/IKEv2 tunneling protocols, firewall policy verification.

Unit V- Scalability & Reliability Theory - (7 Hours)

Elasticity Frameworks: Autoscaling hysteresis models, M/M/c queueing systems, horizontal scaling proofs. Failure Engineering: Weibull failure distributions, RTO/RPO calculus, chaos engineering principles. Cost Governance Ontologies: TCO analytical frameworks, bin packing optimization, cloud governance taxonomies.

Learning Resources

Text Books:

1. T. Erl et al., Cloud Computing: Concepts, Technology & Architecture. Upper Saddle River, NJ: Prentice Hall, 2013.
2. D. Dutt, Cloud Native Data Center Networking. Sebastopol, CA: O'Reilly Media, 2019.
3. B. Beyer et al., Site Reliability Engineering: How Google Runs Production Systems. Sebastopol, CA: O'Reilly Media, 2016.
4. C. Wu and R. Buyya, Cloud Data Centers and Cost Modeling: A Complete Guide To Planning, Designing and Building a Cloud Data Center. Cambridge, MA: Morgan 2015

Reference Books:

1. R. Mather et al., Cloud Security: A Comprehensive Guide to Secure Cloud Computing. Hoboken, NJ: Wiley, 2010.
2. P. Mell and T. Grance, The NIST Definition of Cloud Computing, NIST SP 800-145. Gaithersburg, MD: National Institute of Standards and Technology, 2011.
3. A. Azodolmolky, Cloud Networking: Understanding Cloud-Based Data Center Networks. Waltham, MA: Morgan Kaufmann, 2014.

SWAYAM/ MOOC / eBooks

1. Cloud computing By Prof. Soumya Kanti Ghosh, IIT haragpur
   https://onlinecourses.nptel.ac.in/noc21_cs14/preview
2. Advanced Computer Networks, By Prof. Neminath Hubballi, Prof. Sameer G Kulkarni IIT Indore, IIT Gandhi nagar
   https://onlinecourses.nptel.ac.in/noc25_cs02/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet of Things**		
PEC-572D-IOT -Smart Healthcare IOT Systems (Elective III)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses: Embedded Systems and Analog Circuits

Course Objectives: The course aims -

- To understand the significance of the Internet of Things in IoT.
- To understanding of wearable technology devices and it's application
- To impart knowledge about data aggregation techniques in healthcare IoT.
- To demonstrate security issues and solutions.
- To demonstrate a routing mechanism for healthcare IoT

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

CO1. Demonstrate knowledge and understanding of the Internet of Medical Things.
CO2. Investigate various wearable devices in healthcare IoT.
CO3. Conceptually describe sensor data aggregation techniques for an IoT healthcare system.
CO4. Compare and analyses various security solutions for healthcare IoT
CO5. Conceptually analyses routing requirements for healthcare IoT.

Course Contents

Unit I – Introduction to IoT in Smart Healthcare - (9 Hours)

Evolution of smart healthcare using IoT, Future of IoT in Healthcare, Challenges in current healthcare systems, IoT healthcare services, Internet of Medical Things (IoMT), Components, Architecture of IoMT System, Benefits and impact of Internet of Medical Things (IoMT), Applications of IoMT, Big data in IoT, Wireless Body Area Networks (WBAN), Routing Protocols, Medium access control.

Unit II – Wearable Devices- (9 Hours)

Bio-sensors: Introduction, Working Principle, Different Types of biosensors, Applications, Wearable Devices – Introduction, Evolution Portable devices, Attachable devices, Implantable and Ingestible devices.

Unit III – Data Aggregation Techniques- (9 Hours)

Challenges in data aggregation in IoMT, Network Communications for health sensor data, Challenges of health care data sharing, health data aggregation techniques in IoT, design and implementation of interoperable IoT healthcare system.

Unit IV- Routing and Security- (8 Hours)

Routing Protocols for IOT healthcare, Routing for intrabody communications, Routing for extra-body communications, MAEB Routing- QoS. Security and Privacy issues with IoT in healthcare, cyber security solutions for healthcare IoT, IoT discovery and Risk analysis, IoT policy management, IoT Threat Prevention.

Unit V- IoMT Applications- (8 Hours)

Smart continuous glucose monitoring (CGM) and insulin pens, connected contact lenses, Connected inhalers, GPS Smart Sole, Remote Patient Monitoring, Efficient Drug Management, Medical Waste Management, IoT Heart Rate Monitoring, Epileptic Seizure Detection and Monitoring.

Learning Resources

Text Books:

1. Krishna P. Venkata, Sasikumar Gurumoorthy, Mohammad S.Obaidat, Internet of Things and Personalized Healthcare Systems, Springer-2019.
2. Pattnaik, Prasant Kumar, Mohanty, Suneeta, Mohanty, Satarupa, Smart Healthcare Analytics in IoT Enabled Environment, Springer-2020.
3. Avijit Mathur, Thomas Newe, Walid Elgenaidi, Muzaffar Rao, Elfed Lewis and Daniel Toal, Medical IoT systems: architecture and security by Wearable Sensors, 2017.
4. Amit Banerjee, Lalit Garg, Joel J. P. C. Rodrigues —Internet of Medical Things for Smart Healthcare‖ Springer Singapore, 2019

Reference Books:

1. Valentina Emilia Balas and Souvik Pal, Healthcare Paradigms in the Internet of Things Ecosystem, Academic Press, 2021.
2. Arshdeep Bhaga and Vijay Madisetti, Internet of Things: A Hands-on Approach, Universities Press, 2015.
3. Rajkumar Buyya and Amir Vahid Dastjerdi, Internet of Things Principles and Paradigms .

SWAYAM/ MOOC / eBOOKS

1. Cloud computing By Prof. Soumya Kanti Ghosh, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_cs14/preview
2. Advanced Computer Networks, By Prof. Neminath Hubballi, Prof. Sameer G Kulkarni, https://onlinecourses.nptel.ac.in/noc25_cs02/preview
3. Cloud Computing and Distributed Systems By Prof. Rajiv Misra IIT Patna

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet Of Things**		
SEM-581-IOT – Seminar- I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 04 Hours/Week	02	**Term Work:** 25 Marks **Practical:** 25 Marks

Course Description:

The seminar aims to enhance students' research, presentation, and critical thinking skills, preparing them for advanced academic pursuits and professional careers. Seminars will provide students with the opportunity and support to improve their self-study skills using modern information technologies and apply new knowledge and skills in practice, including in new areas.

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

- **Deepen Technical Knowledge:** To enable students to explore a specialized topic within E&TC Engineering beyond the regular curriculum, fostering in-depth understanding.
- **Develop Research Skills:** To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
- **Enhance Communication Skills:** To cultivate effective oral and visual presentation skills, enabling students to articulate complex technical concepts clearly and concisely to a knowledge-able audience.
- **Foster Critical Thinking:** To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
- **Promote Independent Learning:** To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
- **Prepare for Thesis/Dissertation:** To serve as a foundational step for the Master's thesis/dissertation, allowing students to explore potential research areas.

Course Outcomes: After successful completion of the course, learner will be able to:

- **CO1: Formulate** the goals and objectives of scientific research;
- **CO2:** Search, evaluate and **analyze** information about the achievements of science and technology in the target area and beyond;
- **CO3: Interpret** data from different fields of science and technology;
- **CO4: Build** the logic of reasoning and statements;
- **CO5: Create**, design and edit text documents in accordance with the requirements of the organization or publisher;

Guidelines

- **Responsibility of the students:**
  - The Seminar should be carried out individually by each student.
  - A student should identify the area or topics in recent trends and developments in consultation with the guide
  - A student should report to his/her respective guide regularly (at least once in a week) and report the progress of the seminar work.
  - A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
  - Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.
  - A student should conduct the research ethically, adhere to the academic integrity stan- dards, and cite sources whenever using any existing results
  - A student should Incorporate constructive feedback to improve the quality and rigor of the research
  - For final examination, students should complete the Seminar Report in all aspects includ- ing formatting and citation.
  - Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
  - A student should invest time and effort in preparing for seminar presentations and the oral defense of the seminar
- **Topic Selection**
  - Relevance: Topics must be directly related to E&TC Engineering, encompassing current research trends, emerging technologies, advanced concepts, or interdisciplinary applications.
  - Scope: The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
  - Novelty (Desired): While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
  - Guide / Supervisor Approval: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
  - Examples of Broad Areas: VLSI Design, Embedded Systems, Artificial Intelligence/ Machine Learning, Cloud Computing, Internet of Things (IoT), High-Performance Computing, Computer Vision, Natural Language Processing, Blockchain, Quantum Computing.
- **Seminar Structure and Deliverable:** The technical seminar typically involves the following stages and deliverable

- Topic Proposal (2-3 weeks after topic approval):
- A concise document (1-2 pages) outlining:
- Proposed Seminar Title
- Brief Description/Abstract of the Topic
- Motivation and Relevance to E&TC Engineering
- Preliminary List of Key References (at least 5-7 reputable sources)
- Tentative Scope and Outline of the Presentation
- Submission: To the faculty supervisor for approval.
- Literature Review and Research (Ongoing): Sources: Students must primarily rely on peer-reviewed academic sources (IEEE Xplore, ACM Digital Library, SpringerLink, arXiv, Google Scholar), reputable conference proceedings, and established industry standards. Wikipedia and unverified blogs are generally not acceptable as primary sources.
- Critical Analysis: Beyond mere summarization, students are expected to critically analyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
- Note-Taking & Organization: Maintain systematic notes and organize research material effectively.

- Seminar Report/Paper (Due 2-3 weeks before presentation):
  - A written report (typically 15-25 pages, excluding references and appendices) detailing the seminar content.
  - Format: Follow a professional academic paper format (e.g., IEEE transaction style).
  - Sections:
    * Abstract: A concise summary of the seminar topic and key findings.
    * Introduction: Background, motivation, problem statement (if applicable), and outline of the report.
    * Literature Review/Background: Detailed discussion of relevant concepts, theories, and existing work.
    * Core Content: In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
    * Analysis/Discussion: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
    * Future Trends/Conclusion: Summarization of key takeaways, potential future directions, and concluding remarks.
    * References: A comprehensive list of all cited sources, properly formatted.
    * Appendices (Optional): Supplementary material if necessary.
- Oral Presentation:
  - Duration: Typically, 25-30 minutes for presentation, followed by 10-15 minutes for Q&A.

(Specific timings will be announced)
- Audience: Faculty members, peers, and potentially other interested individuals.
- Content: The presentation should effectively convey the key aspects of the seminar topic. It should not simply be a reading of the report.
- Visual Aids: High-quality presentation slides (e.g., PowerPoint, Google Slides, LaTeX Beamer) are mandatory. Slides should be clear, concise, visually appealing, and support the oral delivery. Avoid excessive text on slides.
- Delivery: Clear articulation, confident posture, good eye contact, and appropriate pace. Practice the presentation thoroughly.
- Q&A Session: Be prepared to answer questions from the audience on all aspects of the seminar topic. Demonstrate a strong understanding and ability to defend your perspec- tives.

- **Evaluation Criteria:** The seminar will be evaluated based on the following criteria:
  - Topic Selection and Scope (10%): Relevance, timeliness, and appropriate depth of the chosen topic. Clarity and focus of the topic proposal.
  - Literature Review and Research (25%): Breadth and depth of literature surveyed. Quality and credibility of sources used. Critical analysis and synthesis of information.
  - Seminar Report/Paper (30%): Clarity, organization, and logical flow of content. Technical accuracy and depth of discussion. Adherence to academic writing standards (grammar, spelling, formatting, referencing). Originality in synthesis and critical insights. Absence of plagiarism.
  - Oral Presentation (35%): Content: Clarity, completeness, and accuracy of the presented material. Organization: Logical flow, effective use of time. Visual Aids: Quality, clarity, and effectiveness of slides. Delivery: Confidence, clarity of speech, enthusiasm, engagement with the audience. Q&A: Ability to answer questions accurately, comprehensively, and confidently.

Learning Resources

1. "Engineering Communication" by Charles W. Knisely & Karin I. Knisely
2. "Technical Communication: Principles and Practice" by Meenakshi Raman & Sangeeta Sharma
3. "The Craft of Scientific Presentations" by Michael Alley

NPTEL Courses

1. https://nptel.ac.in/courses/109/106/109106180/
2. https://www.udemy.com/course/technical-writing/
3. https://www.edx.org/course/writing-in-the-sciences

Savitribai Phule Pune University, Pune

Maharashtra, India

M.E .– Internet of Things 2025 Pattern

Semester III

Savitribai Phule Pune University Master of Engineering (2025 Course) - Internet of Things		
RM-601-IOT - Research Methodology		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 05 Hours/Week	05	**CCE:** 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Familiarity with project-based learning (e.g., mini projects, seminars, undergraduate theses)
2. Knowledge of basic statistics (mean, median, variance, standard deviation, probability concepts)
3. Basic skills in technical writing (reports, presentations, documentation).
4. Sound fundamentals of the core engineering/science domain

Course Objectives: The course aims to:

1. Understand the philosophy of research in general
2. Understand basic concepts of research and its methodologies
3. Learn the methodology to conduct the Literature Survey
4. Acquaint with the tools, techniques, and processes of doing research
5. Learn the effective report writing skills and allied documentations
6. Become aware of the ethics in research, academic integrity and plagiarism

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

- **CO1:** Define research and explain its essential characteristics with examples from engineering and science fields.
- **CO2:** Identify and apply different types of research (basic, applied, qualitative, quantitative, exploratory, descriptive, etc.) to specific problems.
- **CO3:** Analyze the outcomes of research such as publications, patents, and technological contributions, and understand their societal and industrial impacts.
- **CO4:** Apply ANOVA and ANCOVA techniques for effective experimental data analysis and interpretation of results.
- **CO5: Understand** and **apply** the basics of Intellectual Property Rights (IPR) to safeguard innovative research and prevent unethical practices.

Unit I - Definition and Characteristics of Research: - (12 Hours)

Basic of Research: Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Philosophy and validity of research. Objective of research. Various functions that de- scribe characteristics of research such as systematic, valid, verifiable, empirical and critical approach. Types - Pure and applied research. Descriptive and explanatory research. Qualitative and quantitative approaches.

Engineering Research: Why? Research Questions, Engineering Ethics, conclusive proof-what constitutes, A research project-Why take on?

Case Study: Code of Ethics, IEEE Code of Ethics, ACM Software Engineering Code of Ethics and Professional Practice, Code of Ethics especially covering Engineering discipline, various aspects-environment, sustainable outcomes, employer, general public, and Nation, Engineering Disasters.

Unit II - Literature Search and Review - (12 Hours)

Literature Review, Types of review, Developing the objectives, Preparing the research design include-Ing sample Design, Sample size. Archival Literature, why should engineers be ethical? Types of publications- Journal papers, conference papers, books, standards, patents, theses, trade magazine, newspaper article, infomercials, advertisement, Wikipedia & websites, Measures of research impact, publication cost.

Case Study: Engineering dictionary, Shod ganga, The Library of Congress, Research gate, Google Scholar, Bibliometrics, Citations, Impact Factor, h-index, I-index, plagiarism, copyright infringement

Unit III - Analysis of Variance and Covariance: - (12 Hours)

Basic principle of Analysis of Variance, ANOVA Technique, Setting up Analysis of Variance Table, short-cut method for oneway ANOVA, Coding method, Two-way ANOVA, ANOVA in Latin-square design, analysis of co-variance (ANCOVA), assumptions in ANCOVA. Academic Ethics: Plagiarism, exposure on anti-plagiarism tools.

Unit IV - Technical Writing and IPR - (12 Hours)

Academic writing, sources of information, assessment of quality of journals and articles, writing scientific report, structure and component of research report, types of report – technical reports and thesis, SCOPUS Index, citations, search engines beyond google, impact factor, H-Index. IPR: What is IPR?, importance of patents, types of IPR, process of patent.

Unit V - Outcome of Research and Research Presentation: - (12 Hours)

Relevance, interest, available data, choice of data, Analysis of data, Generalization and interpretation of analysis, Preparation of the Report on conclusions reached, testing validity of research outcomes, Suggestions and recommendations, identifying future scope.

Research presentation: Introduction, Standard terms, Standard research methods and experimental techniques, Paper title and keywords, Writing an abstract, Paper presentation and review, Conference presentations, Poster presentations, IPR, Copyright, Patents.

Case Study: Intellectual Property India- services, InPASS - Indian Patent Advanced Search System, US patent, IEEE / ACM Paper templates.

Learning Resources

TextBooks

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers' Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd.ed), Singapore, Pearson Education.
4. Neeraj Pandey, Intellectual Property Rights ,1st Edition, PHI
5. Shrivastava, Shenoy& Sharma, Quantitative Techniques for Managerial Decisions, Wiley

Reference Books:

1. Goode W J &Hatt P K, Methods in Social Research, McGraw Hill
2. Basic Computer Science and Communication Engineering – R. Rajaram (SCITECH)

SWAYAM / MOOC / YouTube Links

1. https://www.youtube.com/playlist?list=PLm-zueI9b64QGMcfn5Ckv_8W5Z1d3vMBY
2. https://onlinecourses.swayam2.ac.in/cec20_hs17/preview
3. https://onlinecourses.nptel.ac.in/noc23_ge36/preview

Practical Assignments / Mini Project Problem Statements		
Sr.	**Title**	**Objectives**
1	Problem Identification Exercise	Identify and clearly define a real-world research problem in your engineering discipline.
2	Literature Review Report	Conduct a detailed literature survey (minimum 30 research papers) and summarize gaps in existing research.
3	Research Proposal Drafting	Prepare a structured research proposal including problem statement, objectives, scope, and methodology.
4	Hypothesis Formulation	Develop testable hypotheses based on selected research problems.
5	Design of Experiment	Design a detailed experimental plan or simulation for validating hypotheses.
6	Sampling Techniques	Select and justify a sampling method for data collection in your project.
7	Data Collection Tools Development	Design a survey questionnaire or sensor-based data collection method.
8	Statistical Data Analysis	Perform statistical analysis (ANOVA, regression, t-tests) on sample data.
9	Research Paper Writing	Draft a full research paper based on hypothetical or preliminary data.
10	Research Ethics and Plagiarism Check	Analyze ethical aspects and conduct a plagiarism check for your paper.

Mini Project statement list for Research Methodology (ANY ONE)		
Sr.	**Project Title**	**Description/Deliverable**
1	AI-based Systematic Literature Review Tool	Build a tool that automates screening and organizing research papers.
2	Comparison of Research Methodologies	Compare qualitative vs. quantitative methods through case studies.
3	Development of a Research Gap Identification Model	Create an algorithm that detects research gaps from published articles.
4	Design of a Predictive Analytics Model	Design a model that predicts the future trend of research in a selected field.
5	Big Data Analysis for Research Trends	Analyze publication data from Scopus/IEEE/Google Scholar to identify top emerging topics.
6	AI-based Systematic Literature Review Tool	Build a tool that automates screening and organizing research papers.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Internet of Things		
RM-602-IOT – OJT/INTERSHIP		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 06 Hours/Week	03	**CCE:** 25 Marks **End-Semester**: 25 Marks

Course objectives:

1. To put theory into practice. And expand thinking and broaden the knowledge and skills acquired through course work in the field.
2. To relate to, interact with, and learn from current professionals in the field.
3. To understand and adhere to professional standards in the field.
4. To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
5. To develop the initiative and motivation to be a self-starter and work independently.

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

- **Gain** practical experience within industry in which the internship is done.
- **Acquire** knowledge of the industry in which the internship is done.
- **Apply** knowledge and skills learned to classroom work.
- **Develop** and refine oral and written communication skills.
- **Acquire** the knowledge of administration, marketing, finance and economics.

Course Description:

1. Internship/On Job Training provide students the opportunity of hands-on experience that includes personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.
2. An internship is the phase of time for students when they are trained for their skills, they are good at, and it gives them a chance to apply their knowledge practically in industries
3. The internship can be carried out in any industry/R&D Organization/Research Institute/Institute of national repute/R&D Centre of Parent Institute.
4. The Department/college shall nominate a faculty to facilitate, guide and supervise students under internship.

Guidelines

- **Purpose:** Internships are designed to bridge the gap between academic learning and industry practice. They aim to provide hands-on experience, expose students to the industrial environment, develop technical and soft skills (communication, teamwork, problem-solving), and help in career exploration.
- **Internship Duration and Academic Credentials**
  - Student can take internship work in the form of Online/Offline mode from any of the Industry / Government Organization Internship Programmes approved by SPPU/AICTE/UGC portals
  - A intern is expected to spend 10 - 12 hours per week on Internship, Training will result in about 160-170 hours of total internship duration.
  - The minimum requirement regarding Internship duration should not be below 8 weeks
- **Type of Internship**
  - o Industry/Government Organization Internship: Working directly with a company or government body.
  - o Research Internship: Focused on research projects, often in collaboration with academic institutions or R&D labs.
  - o Innovation/Entrepreneurship: Working on developing new products, processes, or even starting a venture.
  - o Social Internship: Engaging in community-based projects.
- **Assessment Details (TW and Practical)**
  - Term work for 100 marks
  - A daily log submitted by the student and a work log signed by the office HoDs where the student has interned will be considered towards the TW marking.
- **Indicative list of areas for OJT**
  - Trade and Agriculture
  - Economy & Banking Financial Services and Insurance
  - Logistics, Automotive & Capital Goods
  - Fast Moving Consumer Goods & Retail
  - Information Technology/Information Technology Enabled Services & Electronics
  - Handcraft, Art, Design & Music
  - Healthcare & Life Science
  - Sports, Wellness and Physical Education

- Tourism & Hospitality
- Digitization & Emerging Technologies (Internet of Things / Artificial Intelligence / Machine
- Learning / Deep Learning / Augmented Reality / Virtual Reality etc.)
- Humanitarian, Public Policy and Legal Services
- Communication
- Education
- Sustainable Development
- Environment
- Commerce, Medium and Small-Scale Industries

- **Faculty Supervision:** Students are usually assigned an internal faculty guide/mentor who supervises their internship activities. This faculty member acts as a teacher, mentor, and critic, and ensures the internship aligns with academic goals. External Supervision: In many cases, an external expert from the host organization also guides the student.

- **Documentation and Reporting:**
  - Joining Report: To be submitted within a specified time frame (e.g., one week from join- ing).
  - Daily/Periodical Diary: Students are often required to maintain a daily or weekly record of their observations, work, and learning.
  - Internship Report: A comprehensive report detailing the work done, learning outcomes, and achievements during the internship. This report needs to be duly signed by the com- pany official and faculty mentor.
  - Completion Certificate: Issued by the host organization upon successful completion.

- **Evaluation:**
  - Evaluation is typically done by the institute, often within a short period after the internship ends.
  - It may involve presentations, viva-voce examinations, and assessment of the internship report and daily diary.
  - Performance-based feedback from the industry mentor is usually a key component.

Savitribai Phule Pune University **Master of Engineering (2025 Course) - Internet Of Things**		
SEM-603-IOT - Seminar - II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 06 Hours/Week	03	**Term Work:25 Marks** **Practical: 25 Marks**

Course Description:

- Research Project seminar is the first stage of work on a master's thesis. During this course, students gain experience in the field of intellectual property and research ethics. They conduct patent searches and analyze related works to study the current state of the target area.
- Work on the "Research Project seminar" is carried out on the basis of the research and training laboratories of the Institute and the Scientific Library of the Institute/University and in close cooperation with the student's scientific supervisor.
- The aim of the "Research Project Seminar" is to prepare for the implementation of the Final Project and for master's thesis defense. It includes finding or developing methods and tools to solve a stated problem, taking into account the latest research and trends; clarification of requirements for the object under development; planning experiments and tests to prove the effectiveness of the proposed solution

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

- To provide students with the opportunity and support to improve their self-study skills using modern information technologies and apply new knowledge and skills in practice, including in new areas.
- To raise student's awareness in advanced methods of research and mastering the skills to apply them.
- Teach students to find and critically analyze sources of information.
- Develop their ability to build logic of reasoning and statements based on the interpretation of data combined from various fields of science and technology, to make judgments based on incomplete data.
- Improve the student's academic writing experience.

Course Outcomes: After successful completion of the course, learner will be able to:

1. fundamental concepts and categories in the field of scientific research- ways of organizing and planning research
2. relevant information sources that allow him or her to acquire new knowledge and skills in various fields

3. advanced information technologies allowing us to acquire new knowledge in various fields
4. features of the technical and scientific style of writing texts
5. basic concepts of the culture of thinking, logic, rules for constructing reasoning and statements
6. formal apparatus of the logic of constructing reasoning and statements
7. evaluation criteria and methods of handling incomplete data

By the end of the course, students will be able to:

- formulate the goals and objectives of scientific research;
- search, evaluate and analyze information about the achievements of science and technology in the target area and beyond;
- interpret data from different fields of science and technology;
- to build the logic of reasoning and statements;
- write a text in a scientific or scientific and technical style, use the appropriate vocabulary;
- create, design and edit text documents in accordance with the requirements of the organization or publisher;
- plan a pilot study
  - methods of planning scientific research, taking into account the peculiarities of the professional area.
  - methods of collecting and analyzing information on the achievements of science and technology in the target area and beyond.
  - proficiency in preparing publications on the topic of research
  - experience in data integration from different fields of science and technology and building evidence-based judgments.
  - methods of planning an experiment, taking into account the peculiarities of the field of professional activity.

Responsibility of the students:

- The Seminar should be carried out individually by each student.
- A student should identify the area or topics in recent trends and developments in consultation with the guide
- A student should report to his/her respective guide regularly (at least once in a week) and report the progress of the seminar work.

- A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
- Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.
- A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources whenever using any existing results
- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing for seminar presentations and the oral defense of the seminar

Course Contents

Seminars / Assignments

1. Introductory lesson: clarification of the project topic, analysis of the assignment.
2. The structure of scientific texts: abstract, article, presentation, research report, master's thesis.
3. An analytical review on the research topic, its goals and objectives. Related works. Sources of information: open sources, journals, databases and collections of publishers. Citation rules. Scientific ethics. Plagiarism. Presentation and discussion of an in-depth analytical review on the research topic.
4. Scientific novelty. Intellectual property. Patent search: goals and objectives, patent databases, rules for compiling a patent search report.
5. Critical analysis of the related works. Identification and evaluation of methods used by other researchers. Choosing or developing your own method its rational.
6. Research Design Stage: clarification of the requirements for the object being developed (soft-ware, hardware and software system, technical product).
7. Formulation of criteria for the project goal achieving. Determination of ways to confirm the achievement of the set goal. Experimental study of the object under development.
8. Experiment planning.

9. Preliminary report on the Research Project. Discussion of the preliminary results of the project. Recommendations for improvement and revision.

10. Final assessment: Project defense in the form of a presentation as seminar

Learning Resources

TextBooks

1. Kennett, B. (2014). Planning and managing scientific research. ANU Press. https://www.jstor.org/stable/(free access)

2. Sirotinina, N. (2012). History and methodology of computer science. Siberian Federal University. Tomsk: TPU Publishing House.

3. Moore, N. (2006). How to do research: a practical guide to designing and managing research projects. Facet publishing.

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet Of Things**		
RPR-604-IOT - Research Project – I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 18 Hours/Week	09	**Term Work:** 25 Marks **Oral:** 25 Marks

Course Description:

The master's degree culminates in a research project of the student's own design. This research project is documented by a final research report or dissertation. The student's work is guided by an academic supervisor. Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc.

Students are expected to construct a research project that includes original research, deliberate and well considered methodological choices, and shows relevance to significant conversations within the discipline. The dissertation should represent the very best research and analysis a student can produce.

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

1. Demonstrate an ability to plan a research project, such as is required in a research proposal prior to the launch of their work
2. Demonstrate an ability to comply with ethical, safety, and documentation processes appropriate to their project
3. Demonstrate expert knowledge in the subject of their research project, such as through a integrated literature survey
4. Demonstrate expert knowledge in the research methods appropriate to generating reliable data for their research questions
5. Demonstrate the ability to manage projects and to make constructive use of expertise associated with their project, while working as an independent learner
6. Demonstrate an ability to relate their original data to existing literature, or to create an novel synthesis of existing materials
7. Demonstrate an ability to assemble their findings into a substantial piece of writing that presents a clear thesis and a cohesive, evidence-based argument
8. Demonstrate an ability to balance description, analysis, and synthesis within their project report
9. Demonstrate an ability to reflect on the strengths and weaknesses of their research and methodology, with constructive advice on how they might improve their efforts in future work

Course Outcomes:

After successful completion of the course, learner will be able to:

- CO 1 : Demonstrate how to search the existing literature to gather information about a specific problem or domain.
- CO 2 : Identify the state-of-the-art technologies and research in the chosen domain, and highlight open problems that are relevant to societal or industrial needs.
- CO 3 : Evaluate various solution techniques to determine the most feasible solution within given constraints for the chosen dissertation problem.
- CO 4 : Apply E&TC engineering principles related to requirements gathering and design to produce relevant documentation.
- CO 5 : Write a dissertation report that details the research problem, objectives, literature review, and solution architecture.

Guidelines

(a) The dissertation is a year-long project, conducted and evaluated in two phases. It can be carried out either in-house or within an industry as assigned by the department. The project topic and internal advisor (a faculty member from the department) are determined at the beginning of Phase I.

(b) Student is expected to complete the following activities in Phase-I:

i. Literature survey
ii. Problem Definition
iii. Motivation for study and Objectives
iv. Preliminary design / feasibility / modular approaches
v. Design of the research project

Phase 1: Informal conversations

Students are strongly encouraged to discuss possible research project ideas with the internal guide, fellow students, and other research professionals. All research projects begin with open- ended conversations and scoping exercises. These should be non-committal.

Phase 2: Identify topic

The first formal step in the module involves identifying a preliminary project title and writing an abstract of no more than 200 words. This requires submitting a completed registration form. Writing an abstract for a research proposal or for completed research work is an important transferable skill. Students who do not submit a completed registration form will be assigned a project. The project title is understood to be provisional. Supervisors will be assigned to students after the project title/ abstract forms have been submitted. Supervision: A supervisor is required. The main responsibilities of the supervisor are to assist the student with project management and to advise the student on criteria for assessment. You can expect your supervisor to read and comment on a full draft of your research proposal and of your project.

It is a good idea to discuss a time line for your project with your supervisor, and to establish a definite timetable.

Some key points in our advice to students on compliance:

1. allow at least two weeks between submitting an ethics application and the date of your first data collection
2. your supervisor must approve (and sign!) your ethics application before you submit it at departmental level
3. after your protocols have been approved, append a copy of your ethical approval certificate to the dissertation and project proposal.

Phase 3: Project proposal

The proposal should reflect a student's best effort. At the same time, we recognize research often raises new questions. Some redefinitions of topics and titles is common later in the research process. Students should keep their supervisors up to date on these developments, and they can expect a reasonable amount of adaptation.

Phase 4: Term-1 research

Students are expected to commit substantial time during the term to their research project. Supervisions The principal form of academic input for the research project normally comes through discussions with the designated supervisor. The majority of these meetings should be face-to-face, either in person or via video- or audio-conferencing technology.

Students are expected to respect these periods of absence and plan their needs accordingly. One distinction is crucial:

(1) when staff are on leave, they are off work (i.e., not expected to maintain contact with their supervisees or to undertake their duties); however,

(2) when staff are working remotely, they are at work (i.e., expected to maintain contact and to be available for normal duties).

A student's supervisor is not the only person who may advise on projects and writing. Others include peers and subject experts.

Phase 5: Submit project report

The project report with the specific due date must be submitted to Department

Additional Information

- **Research notebook :** Students are strongly advised to maintain a research notebook, either digital or paper, and to keep this up to date. A research notebook can prove useful should examiners query research methods, research integrity, or research process.
- **Preventing data loss:** Protect yourself against loss of research material and writing by maintaining a system for secure, redundant, up-to-date back-up of research material and writing. Loss cannot be accepted as a reason for failing to meet a deadline. A copy of written notebooks can be stored by supervisors for the duration of the project. Loss of project materials through accidents and theft have occurred in the past; these have had devastating effects on the un-

prepared. All students are warned to create redundancies to protect their project from similar calamities.

- **Extensions :** This is a long-term research project, and time management is a learning objective. Short-term extensions normally are not considered. Applications for extension must be made through the processes described in the STS Student Handbook. Personal Tutors are the first point of contact on extension requests.

- **Word counts :** Words counted towards the total word count include the main body of the report and supporting footnotes or endnotes. The word count does not include: bibliography, front matter (title page, keywords, abstract, table of contents, acknowledgments), appendix material, supplemental data packages, table and figure legends, or documentation of ethics protocols or approvals. Otherwise, University standard policy on word counts will apply.

- **Re-using coursework from other modules :** Text and ideas in the research proposal may reappear in the dissertation if significantly developed or further elaborated; however, Universities policy on self-plagiarism prevents the same work receiving credit twice. This means rote duplication is not allowed.

- **Citation format :** The style must be clear, explicit, and meaningful. In every instance, it must allow an examiner to locate efficiently and specifically material referred to. As a recommen- dation, students should use a style frequently used in the literature relevant to their research project. Most journals have style guides in their notes to contributors. Students should dis- cuss options with their supervisors, and they should keep in mind that efficient citation is one element in the criteria for assessment.

Savitribai Phule Pune University, Pune

Maharashtra, India

M.E. – Internet of Things 2025 Pattern

Semester IV

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet Of Things**		
SEM -651-IOT - Seminar III		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 08 Hours/Week	04	**Term Work:**50 Marks **Oral:** 50 Marks

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

- To provide students with the opportunity and support to improve their self-study skills using modern information technologies and apply new knowledge and skills in practice, including in new areas.
- To raise student's awareness in advanced methods of research and mastering the skills to apply them.
- Teach students to find and critically analyze sources of information.
- Develop their ability to build logic of reasoning and statements based on the interpretation of data combined from various fields of science and technology, to make judgments based on incomplete data.
- Improve the student's academic writing experience.

Course Outcomes: After successful completion of the course, learner will be able to:

1. CO1: Formulate the goals and objectives of scientific research.
2. CO2: Search, evaluate and analyze information about the achievements of science and technology in the target area and beyond.
3. CO3: Interpret data from different fields of science and technology.
4. CO4: To build the logic of reasoning and statements.
5. CO5: Write a text in a scientific or scientific and technical style, use the appropriate vocabulary.

Responsibility of the students:

- The Seminar should be carried out individually by each student based on their research project
- A student should identify the area or topics in from the topic selected for research project related recent trends and developments in consultation with the guide
- A student should report to his/her respective guide regularly (at least once in a week) and report the progress of the seminar work.
- A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.

- Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.
- A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources whenever using any existing results
- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing for seminar presentations and the oral defense of the seminar

Learning Resources

1. Kennett, B. (2014). Planning and managing scientific research. ANU Press. https://www.jstor.org/stable/(free access)
2. Moore, N. (2006). How to do research: a practical guide to designing and managing research projects. Facet publishing.

Savitribai Phule Pune University Master of Engineering (2025 Course) – **Internet Of Things**		
RPR-652-IOT - Research Project-II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 36 Hours/Week	18	**Term Work:**150 Marks **Oral :** 50 Marks

Prerequisite: Research Project Stage-I

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

- **Demonstrate** an ability to plan a research project, such as is required in a research proposal prior to the launch of their work
- **Ability** to manage projects and to make constructive use of expertise associated with their project, while working as an independent learner
- **Ability** to relate their original data to existing literature, or to create an novel synthesis of existing materials
- **Identify** and **formulate** a problem of research interest in the chosen area of E&TC.

Course Outcomes: After successful completion of the course, learner will be able to:

1. **CO1: Undertake** independent research that makes an original contribution to knowledge, or produces a novel synthesis of existing materials relevant to significant conversations in the discipline
2. **CO2: Plan** their project in advance, using a proposal to describe their undertaking, describe how it will be managed, and reflect upon its value
3. **CO3: Relate** their original research to existing literature on the subject and relate their work to general themes in their relevant scholarly literature
4. **CO4: Assemble** their rationale, methods, findings, and analysis into a substantial piece of writing that presents a clear thesis and a cohesive evidence-based argument or analysis
5. **CO5: Reflect** on the strengths and weaknesses of their research and methodology, understanding how they might improve their efforts in future work

Guidelines for Research Project

– The student shall consolidate and complete the remaining part of the research work started in Semester III. This will consist of Selection of Technology, Installations, implementations, testing, Results, measuring performance, discussions using data tables per parameter con- sidered for the improvement with existing/known algorithms/systems, comparative anal- ysis, validation of results and conclusions.

- The student shall prepare the duly certified final report of dissertation in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.
- The students are expected to validate their study undertaken by publishing it at standard platforms.
- The investigations and findings need to be validated appropriately at standard platforms like conference and/or peer reviewed journal.
- The student has to exhibit continuous progress through regular reporting and presentations and proper documentation of the frequency of the activities in the sole discretion of the PG coordination/Head of the department. The continuous assessment of the progress needs to be documented unambiguously.
- Supervisor Interaction: Minimum one meeting per week.
- Logbook: Maintain a record of work progress and supervisor comments.
- Ethics: No plagiarism, false results, or unethical practices allowed.
- Backup: Keep source code, datasets, and reports backed up securely.
- Submission Format: Soft copy (PDF) + Hard copy as per institute norms.

- **Key Components:**
  - **Implementation**
    - Complete development/simulation/testing of the system or model.
    - Ensure correctness, efficiency, and validation of results.
  - **Results & Analysis**
    - Include experimental setup, datasets used, performance metrics.
    - Graphs, tables, and comparison with existing techniques.
    - Highlight key findings and their significance.
  - **Conclusion and Future Work**
    - Summarize outcomes, contributions, and applications.
    - Suggest extensions or improvements for future research.
  - **Paper Publication**
    - At least one paper (optional/encouraged) in peer-reviewed conference/journal.
    - Attach publication/proof as appendix (if available).
  - **Final Report Format**
    - Revised version of Stage 1 report with added implementation, results, and conclusion chapters.
    - Maintain academic writing standards and include all necessary references.
  - **Plagiarism Report**
    - Final version must again be checked and should not exceed 15% similarity.
  - **Evaluation Parameters**
    - Completeness and quality of implementation
    - Anaysis and originality of results
    - Qulity of documentation and adherence to format
    - Viv-voce performance and clarity of understanding
    - Contribution to knowledge or innovation

Program Coordinator

Dr. B. D. Jadhav - Member, Board of Studies – E&TC Engineering

Team Members for Course Design

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Dr. Pramod Patil – Faculty of Science and Technology
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