Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

National Education Policy (NEP)-2020 Compliant Curriculum

TE – Third Year Engineering (2024 Pattern)

Electronics & Telecommunication Engineering

(With effect from Academic Year 2026-27)

www.unipune.ac.in

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Nomenclature

CEP	Community Engagement Project
CO	Course Outcome
KAP	Knowledge and Attitude Profile
MDM	Multidisciplinary Minor
OE	Open Elective
PCC	Program Core Course
PO	Program Outcomes
VEC	Value Education Course
VSE	Vocational and Skill Enhancement Course
WK	Knowledge and Attitude Profile

Preface by Board of Studies

Dear Students and Teachers,

We, the members of Board of Studies Electronics and Telecommunication Engineering, are very happy to present Third Year Electronics and Telecommunication Engineering syllabus effective from the Academic Year 2026-27. The present curriculum will be implemented for Third Year of Engineering from the academic year 2026-27. Subsequently this will be carried forward for BE in AY 2027-28, respectively.

Electronics and Telecommunication Engineering is a dynamic discipline that lies at the intersection of electronics engineering and communication technology. It provides the foundation for the design, development, and application of electronic systems and communication devices. This curriculum is designed to provide students with a comprehensive understanding of the fundamental principles, theories, and practices of Electronics and Telecommunication engineering, while also preparing them for the ever-evolving technological landscape.

The revised syllabus falls in line with the objectives of NEP-2020, Savitribai Phule Pune University, AICTE New Delhi, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements. Wherever possible, additional resource links of platforms such as NPTEL, Swayam are appropriately provided at the end of each course. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

This curriculum is the result of extensive consultation with academic experts, industry professionals, and alumni to ensure relevance and excellence. It is designed not only to meet the current industry standards but also to prepare students for higher studies and research in the field of Electronics and Telecommunication engineering.

We hope that this curriculum will inspire students to become competent professionals, responsible citizens, and contributors to the technological advancement of society.

Dr. S. D. Shirbahadurkar
Chairman
Board of Studies

Members of Board of Studies– E&TC Engineering	
Dr. Aditya Abhyankar	Dr. Rawal Awale
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Knowledge and Attitude Profile (WK)

A Knowledge and Attitude Profile (KAP), often represented as WK (Knowledge and Attitude Profile)in some contexts, is a framework or assessment tool used to evaluate an individual's knowledge and attitudes related to a specific area, topic, or domain.

WK1	A systematic, theory-based understanding of the natural sciences Applicable to the discipline and awareness of relevant social sciences.
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals Required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a Practice area.
WK6	Knowledge of engineering practice(technology)in the practice are as In the engineering discipline.
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Programme Outcomes (PO)

Program Outcomes are statements that describe what students are expected to know and be able to do upon graduating from the program. These relate to the skills, knowledge, attitude and behavior that students acquire through the program. On successful completion of B.E. in Electronics and Telecommunication Engineering, graduating students/graduates will be able to:

PO1	Engineering Knowledge	Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution Of complex engineering problems.
PO2	Problem Analysis	Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1toWK4)
PO3	Design / Development of Solutions	Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and Environment as required. (WK5)
PO4	Conduct Investigations of Complex Problems	Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid Conclusions .(WK8).
PO5	Engineering Tool Usage	Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex Engineering problems. (WK2andWK6)
PO6	The Engineer and the World	Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
PO7	Ethics	Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & International laws. (WK9)
PO8	Individual and Collaborative Team Work	Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9	Communication	Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
PO10	Project Management and Finance	Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
PO11	Life-Long Learning	Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)
Reference: Self-Assessment Report (SAR) Format Undergraduate Engineering Programs Graduate Attributes and Professional Competencies Version 4.0 (GAPCV4.0)- (August2024) Page56.		

General Rules and Guidelines

- Course Outcomes (CO): Course Outcomes are narrower statements that describe what students are expected to know, and are able to do at the end of each course. These relate to the skills, knowledge and behavior that students acquire in their progress through the course.
- Assessment: Assessment is one or more processes, carried out by the institution, that identify, collect, and prepare data to evaluate the achievement of Program Educational Objectives and Program Outcomes.
- Evaluation: Evaluation is one or more processes, done by the Evaluation Team, for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which Program Educational Objectives or Program Outcomes are being achieved, and results in decisions and actions to improve the program

Guidelines for Examination Scheme

Theory Examination: The theory examination shall be conducted in two different parts Comprehensive Continuous Evaluation (CCE)and End-Semester Examination (ESE).

Comprehensive Continuous Evaluation (CCE) of 30 marks based on all the Units of course syllabus to be scheduled and conducted at institute level. To design a Comprehensive Continuous Evaluation (CCE) scheme for a theory subject of 30 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr.	Parameters	Marks	Coverage of Units
1	Unit Test	12Marks	Units1&Unit2(6Marks/Unit)
2	Assignments/Case Study	12Marks	Units3&Unit4(6Marks/Unit)
3	Seminar Presentation/Open Book Test/ Quiz	06Marks	Unit5

Comprehensive Continuous Evaluation (CCE) of 15 marks based on all the Units of course syllabus to be scheduled and conducted at institute level. To design a Comprehensive Continuous Evaluation (CCE) scheme for a theory subject of 15 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Sr.	Parameters	Marks	Coverage of Units
1	Unit Test	10Marks	Unit1&Unit2(5Marks/Unit)
3	Seminar Presentation/Open Book Test/ Assignments/Case Study	05Marks	Unit3&Unit4

Note: Students can opt for Open Electives offered by different faculty like Arts, Science, Commerce, Management, Humanities or Inter-Disciplinary studies.
Example Open Elective I-Financial Accounting, Digital Finance, Digital Marketing can be opted from Commerce and Management faculty.
And Elective II - Project Management, Business Analytical, Financial Management can be opted from Inter-Disciplinary studies, Commerce and Management faculty respectively.

- **Unit Test**
  - **Format :** Questions designed as per Bloom's Taxonomy guidelines to assess various cognitive levels (Remember, Understand, Apply, Analyze, Evaluate, Create).
  - **Implementation**: Schedule the test after completing Units 1 and 2. Ensure the question paper is balanced and covers key concepts and applications.
- **Sample Question Distribution**
  - Remembering (2Marks): Define key terms related to Topic from Units 1 and 2.
  - Understanding(2Marks): Explain the principle of Concept in Context.
  - Applying(2Marks): Demonstrate how Concept can be used in Scenario.
  - Analyzing(3Marks): Compare &contrast Two related concepts from Units 1 and 2.
  - Evaluating(3Marks): Evaluate the effectiveness of Theory/Model in Situation.
- **Assignments / Case Study:** Students should submit one assignment or one Case Study Report based on Unit 3 and one assignment or one Case Study Report based on Unit 4.
  - **Format:** Problem-solving tasks, theoretical questions, practical exercises, or case studies that require in-depth analysis and application of concepts.
  - **Implementation:** Distribute the assignments or case study after covering Units3 and 4. Provide clear guide lines and rubric for evaluation.
- **Seminar Presentation:**
  - **Format:** Oral presentation on a topic from Unit 5, followed by a Q&A session.
  - **Deliverables:** Presentation slides, a summary report in 2 to 3 pages, and performance during the presentation.
  - **Implementation:** Schedule the seminar presentations towards the end of the course. Provide students with ample time to prepare and offer guidance on presentation skills.
- **Open Book Test:**
  - **Format:** Analytical and application-based questions to assess depth of understanding.
  - **Implementation:** Schedule the open book test towards the end of the course, ensuring it covers critical aspects of Unit 5.
- **Quiz:**
  - **Format:** Quizzes can help your students practice existing knowledge while stimulating interest in learning about new topic in that course. You can set your quizzes to be completed individually or in small groups.

- **Implementation:** Online tools and software can be used create quiz. Each quiz is made up of a variety of question types including multiple choice, missing words, true or false etc.

- **Example Timeline for conducting CCE:**
  - Weeks1-4: Cover Units1and2
  - Week5: Conduct Unit Test(12marks)
  - Weeks6-8: Cover Units 3and 4
  - Week9: Distribute and collect Assignments/Case Study (12marks)
  - Weeks10-12: CoverUnit5
  - Week13: Conduct Seminar Presentations or Open Book Test or Quiz(6marks)

- **Evaluation and Feedback:**
  - **Unit Test:** Evaluate promptly and provide constructive feedback on strengths and areas for improvement.
  - **Assignments/Case Study:** Assess the quality of submissions based on the provided rubric. Offer feedback to help students understand their performance.
  - **Seminar Presentation:** Evaluate based on content, delivery, and engagement during the Q&A session. Provide feedback on presentation skills and comprehension of the topic.
  - **Open Book Test**: Evaluate based on the depth of analysis and application of concepts. Provide feedback on critical thinking and problem-solving skills.

End-Semester Examination(ESE)

End-Semester Examination (ESE) of 70 marks written theory examination based on all the unit of course syllabus scheduled by university. Question papers will be sent by the University through QPD (Question Paper Delivery). University will schedule and conduct ESE at the end of the semester.

- **Format and Implementation:**
  - **Question Paper Design:** Below structure is to be followed to design an End-Semester Examination (ESE) for a theory subject of 70 marks on all 5 units of the syllabus with questions set as per Bloom's Taxonomy guidelines and 14 marks allocated per unit.
  - **Balanced Coverage**: Ensure balanced coverage of all units with questions that assess different cognitive levels of Bloom's Taxonomy: Remember, Understand, Apply, Analyze, Evaluate, and Create. The questions should be structured to cover:
    - Remembering: Basic recall off acts and concepts.
    - Understanding: Explanation of ideas or concepts.
    - Applying: Use of information in new situations.
    - Analyzing: Drawing connections among ideas.
    - Evaluating: Justifying a decision or course of action.

* Creating: Producing new or original work (if applicable).

- **Detailed Scheme for 70 Marks:** Unit-Wise Allocation (14 Marks per Unit): Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation.
- **Detailed Scheme for 35 Marks:** Unit-Wise Allocation (08 Marks for Unit-I, 09 Marks for Unit-II, Unit III and Unit IV). Each unit will have a combination of questions designed to assess different cognitive levels. By following this scheme, you can ensure a comprehensive and fair assessment of students understand- Understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation.

NEP 2020 Compliant Curriculum Structure

Third Year Engineering(2024Pattern)

Electronics & Telecommunication Engineering

Level 5.0															
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme & Marks						Credits			
			Theory	Tutorial	Practical	CCE*	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
Semester - V															
PCC-301-ETC	Programme Core Course 1	Microcontrollers & applications	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-302- ETC	Programme Core Course 2	Cellular Network	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-303- ETC	Programme Core Course 3	VLSI Design	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-304- ETC	Program Core Course Lab 1	Microcontrollers & VLSI design Lab	-	-	4	-	-	50	25	-	75	-	-	2	2
PCC-305- ETC	Programme Core Course Lab 2	Cellular Network Lab	-	-	2	-	-	25	25	-	50	-	-	1	1
PEC -321- ETC	Programme Elective Course	Elective-I	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC- 322- ETC	Programme Elective Course Lab	Elective-I Lab	-	-	2	-	-	50	-	-	50	-	-	1	1
MDM- 331-ETC	Multidisciplinary Minor	Machine Learning	-	2	2	-	-	25	-	25	50	-	2	1	3
OLE -341 -ETC	Open Elective	Open Elective	2	-	-	15	35	-	-	-	50	2	-	-	2
ELC -342- ETC	Experiential Learning	Technical Seminar	-	-	2#	-	-	-	-	25	25	-	-	1	1
			14	02	12	135	315	150	50	50	700	14	02	06	22
			28 Hrs.			700 Marks						22 Credits			

Course Code	Program Elective-I
PEC321A- ETC	**Advanced Java Programming**
PEC321B- ETC	**Computer Networks**
PEC321C- ETC	**Digital Signal Processing**
PEC321D- ETC	**Cloud Computing**

2 It shall be conducted for full class not batch wise

*Note: Students can opt for Open Electives offered by different discipline/faculty like Arts, Science, Commerce, Management, Humanities or Inter-Disciplinary studies. Example – Open Elective I- IPR and Cyber Laws, Sustainability Development, Digital Personal Data Protection, The Constitution of India, Marketing Management, Financial risk Managements.

NEP 2020 Compliant Curriculum Structure

Third Year Engineering (2024Pattern)

Electronics & Telecommunication Engineering

Level 5.0															
Course Code	Course Type	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credits			
			Theory	Tutorial	Practical	CCE*	End-Sem	Term work	Practical	Oral	Total	Theory	Tutorial	Practical	Total
Semester -VI															
PCC-351-ETC	Program Core Course 1	Embedded System Design	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-352-ETC	Program Core Course 2	Broadband Communication	3	-	-	30	70	-	-	-	100	3	-	-	3
PCC-353-ETC	Program Core Course	Embedded System Design Lab	-	-	2	-	-	25	25	-	50	-	-	1	1
PCC-354-ETC	Program Core Course Lab	Broadband Communication Lab	-	-	2	-	-	25	-	25	50	-	-	1	1
PEC361-ETC	Programme Elective Course	Elective II	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC362-ETC	Programme Elective Course	Elective III	3	-	-	30	70	-	-	-	100	3	-	-	3
PEC363-ETC	Programme Elective Course Lab	Elective II & III	-	-	2	-	-	25	25	-	50	-	-	1	1
MDM371-ETC	Multidisciplinary Minor	Database Management System	-	1	2	-	-	25	-	25	50	-	1	1	2
VSE372-ETC	Vocational & Skill Enhancement Course	Mini-Project	-	-	2	-	-	50	-	-	50	-	-	1	1
ELC381-ETC	Experiential Learning Course	Internship/OJT	-	-	8	-	-	-	-	50	50	-	-	4	4
Total			12	01	18	120	280	150	50	100	700	12	1	09	22
			31 Hrs.			700 Marks						22 Credit			

Course Code	Program Elective-II	Course Code	Program Elective-III
PEC361A-ETC	**Web Technology**	**PEC362A- ETC**	**Power Electronics**
PEC361B- ETC	**Digital Image Processing**	**PEC362B- ETC**	**Robotics & Automation**
PEC361C- ETC	**Network & Cyber Security**	**PEC362C- ETC**	**Artificial Intelligence**
PEC361D- ETC	**CMOS Process Technology**	**PEC362D- ETC**	**Industrial IOT**

***Comprehensive Continuous Evaluation.**

Savitribai Phule Pune University, Pune

Maharashtra, India

TE -Department of Electronics & Telecommunication Engineering

2024Pattern

Semester- V

With effect from Academic Year 2026–27

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024Course)

PCC-301-ETC: Microcontrollers and Applications

Teaching/scheme	Credits	Examination Scheme
Theory:03Hours/Week	03	**CCE**:30 Marks **End-Semester:**70 Marks

Prerequisite Courses, if any: Digital logic design, Electronic Components and Hardware, Basics of C Language.

Companion Course, if any:

Course Objectives:

To make students understand

- Understand architecture and features of 8051 & LPC2148 Microcontroller.
- Learn interfacing of real-world peripheral devices with Microcontroller
- Implement programming with embedded C
- Design and develop Microcontroller based embedded application
- Demonstrate real-life applications using Microcontrollers

Course Outcomes:

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

CO1: Understand the fundamentals of microcontroller

CO2: Interface of peripheral components with microcontrollers

CO3: Interface of peripheral components with microcontrollers

CO4: Interface of peripheral components with microcontrollers

CO5: Develop real-life applications

Course Contents

Unit I	Introduction to Microcontrollers	(09Hours)

Introduction to Microcontroller, Comparison between Microprocessors and Microcontrollers Architecture: Von Neumann vs. Harvard architecture, Introduction to Hardwire and ISA Architecture, CISC vs. RISC and pipeline execution, Evolution and Comparison between 8,16-,32 and 64-bit microcontrollers, Selection Criteria of Microcontrollers, Introduction to 8-bit microcontroller (8051), features, Block diagram, Register model, Memory organization, Interrupt Structure. Serial Communication.

Mapping of Course Outcomes for Unit I	CO1: Understand the fundamentals of microcontroller

Unit II	Programming with 8 bit Microcontroller (8051)	(08 Hours)

Pin out diagram of 8051, Port Structure, Timer / Counter, Delay Calculation and Programming, Programming of ports, Interfacing of LED, LCD, LDR, 7- segment display, Relays, Buzzer, with Embedded C programs. Application: Design of Data Acquisition System.

Mapping of Course Outcomes for Unit II	CO2: Interface of peripheral components with microcontrollers

Unit III	ARM7 Processor Fundamentals & Architecture	(08 Hours)

Introduction to ARM processors and its versions, ARM Core data flow model, programmers' model, modes of operations, Registers, CPSR, SPSR Comparison of ARM7, ARM9 & ARM11 processors. ARM7 Based Microcontroller LPC2148: Features, Architecture (Block Diagram and Its Description, Memory Map, GPIO, Pin Connect Block.		
Mapping of Course Outcomes For Unit III	CO3: Analyze application-based design using ARM LPC2148	
Unit IV	**ARM7 Based Microcontroller Interfaces**	**(09 Hours)**
System Control Block: Phase Locked Loop (PLL) configuration, Power Control, and VPB (VLSI Peripheral Bus) Divider. Timers: Architecture of 32-bit timers (Timer 0 and Timer 1), match registers, and pre-scalers. Interrupt structure of LPC2148, interfacing with LED, GLCD, KEYPAD, simple LPC2148 GPIO Programming examples Using timers of LPC2148 to generate delay.		
Mapping of Course Outcomes For Unit IV	CO4: Explore the programming details with peripheral interfaces	
Unit V	**Real World Interfacing With ARM**	**(09 Hours)**
Serial communication programming for transmission and reception from computer, programming for UART. Analog-to-Digital Converter (ADC): Features of the 10-bit ADC, conversion times, and channels. Digital-to-Analog Converter (DAC): Generating analog output waveforms GSM and GPS module interfacing, EEPROM interface using I2C, SDCARD using SPI.		
Mapping of Course Outcomes for Unit V	CO5: Develop real-life applications	

Learning Resources

Text Books:

1. Mahumad Ali Mazadi, Janice Gillispie Mazadi, Rolin D McKinlay —The 8051 Microcontroller & Embedded Systems (Using Assembly and C) ‖ 2nd Edition, PHI.
2. Andrew Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide – Designing and Optimizing System Software", ELSEVIER.
3. LPC 214x User manual (UM10139) :- www.nxp.com

Reference Books:

1. Kenneth J. Ayala, 'The 8051 Microcontroller Architecture, Programming and Applications', Cengage Learning. Second edition.
2. Ajay Deshmukh, 'Microcontrollers Theory and Applications', TATA McGraw Hill.
3. Dr. K.V.K Prasad, "Embedded / Real-Time Systems: Concepts, Design and Programming
4. Black Book", Dream Tech Publishers
5. Michael Barr and Anthony Massa, "Programming Embedded Systems: With C and GNU Development

MOOC/NPTEL Courses:

1. NPTELCourse **"Microcontroller and Applications "**

Link:https://nptel.ac.in/courses/117/104/117104072/
https://nptel.ac.in/courses/108/105/108105102/
http://digimat.in/nptel/courses/video/106105193/L05.html
NPTELCourse **"vlabs.iitb.ac.in"**
Link:http://vlabs.iitb.ac.in/vlabs-dev/labs/8051-Microcontroller-Lab/labs/index.php

Savitribai Phule Pune University

Third Year of Electronics and Telecommunication Engineering(2024Course)

PCC-302-ETC: Cellular Network

Teaching/scheme	Credits	Examination Scheme
Theory:03Hours/Week	03	**CCE**: 30Marks **End-Semester:**70Marks

Prerequisite Courses , if any: Communication Systems

Companion Course, if any: Cellular Networks Lab

Course Objectives:

To make students understand

- Aspects of digital communication system.
- Propagation Model and Estimation techniques of wireless communication system.
- OFDM and MIMO technologies to explain modern wireless systems.
- Aspects of wireless-system planning.
- Generation of Mobile Networks.
- Diversified issues that can enhance Network Performance.

Course Outcomes:

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

CO1: Understand digital modulation techniques and their use in digital communication systems.

CO2: Apply basics of wireless communication fundamentals**.**

CO3: Apply OFDM and MIMO concepts.

CO4: Analyze aspects of wireless system planning**.**

CO5: Analyze the performance of cellular networks using key performance parameters, and optimization techniques to identify and resolve network issues

Unit I	Introduction to Digital Communication	(09Hours)

Need and advantages of digital communication. Basic block diagram of digital communication system. Digital data representation. Types of Digital Modulation techniques ASK, PSK, QPSK, QAM (M-ary coding) based on bandwidth and power considerations. Data transmission efficiency. Bit Rate, Baud Rate and Symbol Rate. Signal space representation. ISI-Inter Symbol Interference Definition and causes of ISI-Channel distortion effects, Pulse spreading and delay spread, Nyquist criterion for zero ISI, Eye diagrams and interpretation, ISI reduction methods. Introduce the application of Digital Communication-List (Cellular Communication, Satellite Communication, Wireless Communication). Numerical on Bit per symbol calculation ,Calculate Baud Rate ,Symbol rate, Bandwidth.

#Exemplar	1. Increasing Mobile Internet Speed Using M-ary Modulation A Wi-Fi router must transmit HD video with high speed and minimum delay. The router uses 64-QAM modulation to send more bits per symbol. A satellite communication system must transmit signals over long distances with less error. The system uses QPSK modulation.
Mapping of Course Outcomes for Unit I	CO1: **Understand** digital modulation techniques and their use in digital communication systems.

Unit II	Introduction to Mobile-Wireless communication channel	(09Hours)
Introduction to radio wave propagation, Free space propagation model, Ground-Reflection Scenario, Hata Model and Receiver-Noise Computation. Channel Estimation techniques and Diversity in wireless communications. Evolution of Mobile Radio Communication, Introduction to Cellular Service Progression, Cell Geometry, Overview of Cellular mobile and Network architecture, Cellular radio system design: Frequency assignments, frequency reuse channels, Concept of cell splitting and Cell sectoring. Significance of Handover in cellular systems with Handoff and roaming.		
#Exemplar	1. Ground-Reflection Scenario (Two-Ray Model), Empirical model for urban, suburban, and rural areas. Channel Estimation Techniques such as Pilot-based estimation, Blind estimation 2. Mobile radio such as police and taxi services. Analog cellular systems like AMPS (Advanced Mobile Phone System) introduced frequency division multiple access (FDMA). Digital systems (GSM, CDMA), WCDMA, All-IP networks, LTE, 5G, Ultra-low latency. Overview of Cellular Mobile Network Architecture.	
Mapping of for Unit II	CO2: **Apply** basics of wireless communication fundamentals.	
Unit III	**Orthogonal Frequency Division Multiplexing and MIMO**	**(09Hours)**
Introduction, Motivation and Multicarrier basics, OFDM, Basic Concept of bit error rate for OFDM, Multiple-Input Multiple-Output Wireless Communications: Introduction to MIMO Wireless Communications, MIMO System Model and MIMO-OFDM, advantages, Effect of Frequency Offset in OFDM, Numerical on SNR/SINR.		
#Exemplar	Use of OFDM in the following: Wi-Fi (802.11), LTE, 5G NR, DVB, video streaming, IoT, AR/VR,	
Mapping of Course Outcomes for Unit III	CO3: **Apply** OFDM and MIMO concepts.	
Unit IV	**Wireless System Planning, Technologies and Protocols**	**(09Hours)**
Link-Budget Analysis, Tele-traffic Theory, Tele-traffic System Model and Steady State Analysis. Introduction, Wireless and mobile technologies, LTE- advanced, 5G – Architecture, wireless local area network and Simulations of wireless networks.		
#Exemplar	Use of Wi-Fi/WLAN in IP based cellular network such as video calling.	
Mapping of Course Outcomes for Unit IV	CO4: **Analyze** aspects of wireless system planning.	
Unit V	**Performance Evaluation and Analysis Issues**	**(09Hours)**
Cellular Network Performance Evaluation, need for performance evaluation, Cellular network performance requirements, Quality of Service (QoS), Key Performance Parameters, Signal strength and signal quality, RSSI, RSRP, RSRQ, SINR, Throughput and bandwidth utilization, Latency. Cellular Network Evaluation Techniques, KPI-based performance monitoring, Drive testing methods, Simulation-based analysis, Traffic analysis and measurement, Real-time monitoring systems, Performance		

Analysis Issues in Cellular Networks, Coverage Issues, Capacity Issues, Mobility issues, Interference issues, Data Service issues. Performance Optimization Techniques Cell splitting and sectoring, Load balancing, Power control methods.	
#Exemplar	Tracking Radiation Levels of a Mobile Tower (Using G-Net Tracker Mobile app) It will measure
Mapping of Course Outcomes for Unit V	CO5: **Analyze** the performance of cellular networks using key performance parameters, and optimization techniques to identify and resolve network issues.

Learning Resources

Textbooks:

1. Bernard Sklar, Prabitra Kumar Ray, "Digital Communications Fundamentals and Applications", Pearson Education, 2nd Edition.
2. Theodore S. Rappaport – Wireless Communications: Principles and Practice
3. Aditya K Jagannatham- Principles of Modern Wireless Communication Systems
4. Jochen Schiller – Mobile Communications
5. Advanced Electronic Communication System-Wayne Tomasi ,6th Edition

Reference Books:

1. B. P. Lathi, "Modern Digital and Analog Communications Systems". Oxford university press, 2015, 4th Edition.
2. Simon Haykin, "Digital Communication Systems", John Wiley & Sons, 4th Edition.
3. Andrea Goldsmith – Wireless Communications
4. William Stallings – Wireless Communications and Networks
5. William Stallings-Network Security Essentials
6. Jeffrey G Andrews, Abhishek K Gupta, Harpreet S Dhillon -An Introduction to Cellular Network Analysis using Stochastic Geometry
7. Cristopher Cox, "An Introduction to LTE: LTE, LTE-Advanced, SAE, VoLTE and 4G Mobile Communications", Wiley, 2nd Edition.
8. E. Dahlman, J. Skold, and S. Parkvall, "4G, LTE-Advanced Pro and The Road to 5G", Academic Press, 3rd Edition.
9. Obaidat, P. Nicopolitids, "Modeling and simulation of computer networks and systems: Methodologies and applications" Elsevier, 1st Edition.

MOOC/NPTEL/YouTube Links:

1. NPTEL Course "**Introduction to Wireless & Cellular Communications**"

Link: https://nptel.ac.in/courses/106/106/106106167/

2. NPTEL Course "**Advanced 3G and 4G Wireless Mobile Communications**"

Link: https://nptel.ac.in/courses/117/104/117104099/

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering(2024Course)

PCC-303-ETC: VLSI Design

Teaching/scheme	Credits	Examination Scheme
Theory:03Hours/Week	03	**CCE:**30Marks **EndSem:**70Marks

Prerequisite Courses, if any:

Course Objectives:

To make students understand

- To understand fundamentals of Verilog, design hierarchy and basic Verilog examples using hierarchical modeling.
- To analyze combinational logic and their applications viz. Multiplexer, Decoder, Adder
- To analyze sequential logic and their applications viz. Flip-flops, Registers, Counters, Shift registers.
- To understand the concepts of state machines.
- To understand the FPGA architecture and design flow.

Course Outcomes:

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

CO1: Explain the fundamentals of Verilog HDL including design hierarchy, levels of abstraction and hierarchical modeling.

CO2: Design and implement combinational logic circuits using Verilog.

CO3: Design and implement sequential circuits using Verilog.

CO4: Design and implement Finite State Machines using Verilog.

CO5: Elaborate FPGA architecture and apply the FPGA design flow for hardware implementation.

Course Contents

Unit I	Introduction to Verilog HDL and Hierarchical Modeling	(09Hours)

Introduction to Verilog HDL, Basic Verilog design flow, Top-down and Bottom-up design methodology, Structure of Verilog modules, Port declarations: input, output, inout, Design hierarchy concepts, Module declaration and instantiation, Levels of abstraction: Behavioral level, Dataflow level, Gate level, Switch level, Compiler directives, System tasks and functions, Simulation and synthesis concepts, Introduction to testbench, Design source and testbench file organization,
Basic Verilog examples using hierarchical modeling.

Exemplar :	Full Adder using two Half Adders, Ripple Carry Adder.
Mapping of Course Outcomes for Unit I	**CO1: Explain the fundamentals of Verilog HDL including design hierarchy, levels of abstraction and hierarchical modeling.**

Unit II	Verilog Fundamentals and Combinational Modeling	(09 Hours)

Net and variable data types: wire, reg, scalar and vector declarations, Number representation, Operators in Verilog, Concatenation and replication operators, Conditional operator, Parameter declaration, Gate-level modeling, Gate delays, Dataflow modeling, Continuous assignment statements, Design of combinational circuits and test benches: Multiplexer, Decoder, Encoder, Adder.

Exemplar	Memory Addressing, Display Driving, Network Address Calculation.

Mapping of Course Outcomes for Unit II	CO2: Design and implement combinational logic circuits using Verilog.	
Unit III	**Behavioral Modeling and Sequential Circuits**	**(09Hours)**
Behavioral modeling concepts, Procedural assignments, initial and always blocks, Event control and sensitivity list, Blocking and non-blocking assignments, if-else and case statements, Edge-triggered sequential modeling, Synchronous and asynchronous reset, Modeling of sequential circuits and test benches: Flip-flops, Registers, Counters, Shift registers, Introduction to timing concepts: Propagation delay, Setup time, Hold time, Clocked sequential circuits.		
#Exemplar	Automotive Microcontrollers, Communications, Consumer Electronics, Automotive Anti-lock Braking Systems.	
Mapping of Course Outcomes for Unit III	CO3: Design and implement sequential circuits using behavioral modeling in Verilog.	
Unit IV	**Finite State Machines and Verilog Applications**	**(09Hours)**
FSM fundamentals, FSM design methodology, Moore and Mealy state machines, State diagram and state table, Next-state and output logic, FSM coding styles, Overlapping and non-overlapping sequence detector, Traffic light controller/Vending machine/Lift controller using Verilog and test bench.		
#Exemplar	ATM machine, vending machine, traffic lights, Communication Protocols: UART, SPI, and I2C use FSMs.	
Mapping of Course Outcomes for Unit IV	CO4: Design and implement Finite State Machines using Verilog.	
Unit V	**FPGA Architecture and Design Flow**	**(09Hours)**
Introduction to PLDs, FPGA and CPLD Architecture; FPGA architecture blocks: CLBs, LUTs, IOBs, Routing resources and programmable interconnects; FPGA design flow: Design entry, Simulation, Synthesis, Implementation, Bitstream generation, Constraint specification, Pin assignment and hardware implementation; FPGA programming techniques, CPLD vs FPGA, JTAG, Boundary Scan		
#Exemplar	5G networking, Autonomous driving, and Aerospace operations.	
Mapping of Course Outcomes for Unit V	CO5: Elaborate FPGA architecture and apply the FPGA design flow for hardware implementation.	

Learning Resources

Textbooks

1. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", SunSoft Press.
2. Stephen Brown and Zvonko Vranesic, "Fundamentals of digital logic with Verilog design", McGraw Hill Publication.

Reference Books:

1. J. Bhaskar, "Verilog HDL Synthesis: A Practical Primer", Star Galaxy Publication
2. Blaine Readler, "Verilog by Example: A Concise Introduction for FPGA Design", Full ARC

Press 3. Clive Maxfield, “The Design Warrior’s guide to FPGA”, Elsevier
MOOC/NPTEL Courses: 4. 1.NPTEL Course “**Hardware Modeling using Verilog**” **Link:**https://nptel.ac.in/courses/106105165 5. 2. NPTEL Course “**System Design Through Verilog**” Link: https://nptel.ac.in/courses/108103179

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024Course)		
PCC-304-ETC: Microcontrollers and VLSI Design Lab		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 04 Hrs/ Week (02hrs for microcontrollers & 2 hrs for VLSI D)	02	**TW:**50 Marks **PR:**25 Marks

Companion Course, if any: Cellular Network

Course Outcome:

CO1: To apply HDL based design techniques for implementing basic VLSI system.

CO2: Design, implement and verify sequential circuits using Verilog.

CO3: Apply HDL based design and verification methodologies to develop simple VLSI system.

List of Experiments

Guidelines for Instructor's Manual

The instructor's manual/Lab Manual is to be developed as a hands-on resource and reference. The instructor's manual needs to include prologue (about University /program/ institute/ department /foreword/ preface), curriculum of course, conduction and Assessment guidelines, topics under consideration-concept, objectives, outcomes, set of typical applications/assignments/guidelines, references.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by student in the form of journal.
Journal consists of prologue, Certificate, table of contents handwritten write-up of each assignment

Content of write-up:

- Title,
- Objectives,
- Problem Statement,
- Outcomes,
- software and Hardware requirements,
- Theory Concept in brief, algorithm, flowchart, test cases, Test Data Set (if applicable), mathematical model (if applicable),
- Results & Discussion
- conclusion.
- Date of Completion,
- Assessment grade/marks and assessor's sign,

Program codes with sample output of all performed assignments are to be submitted as hardcopy.
Microcontroller and Application Lab
Group A (Any Three) 8051
1. Interacting of LEDS—Different programs (flashing, Counter, BCD, HEX,)
2. Interfacing of multiplexed 7-segment display (counting application)
3. Waveform generation using DAC

4. Interfacing of Stepper motor to 8051- software delay using Timer
5. Interfacing of Relay and Buzzer
Group B (Any Five) LPC 2148
6. Interfacing LPC2148 with GLCD to display image on it.
7. Interfacing of 4x4 matrix keyboard with LPC 2148.
8. Using built-in ADC of LPC2148 for displaying its values (Programming built-in ADC with interrupt and without interrupt).
9. Interfacing GPS with LPC2148 for finding current location latitude and longitude values.
10. Interfacing and programming of on-chip RTC.
11. Interfacing EEPROM to LPC2148 using I2C protocol.
12. Interfacing SD card to LPC2148 using SPI.
Virtual LAB Links:
13. **Note: Additional 2 experiments to be performed using the virtual labs.**
VLSI Design Lab
GroupA-Combinational Circuits (Tool: Vivado / ModelSim)(Any 3)
1. Write Verilog and testbench code to implement 4:1 Multiplexer.
2. Write Verilog and testbench code to implement full adder using two half adders.
3. Write Verilog and testbench code to implement 4-bit ALU.
4. Write Verilog and testbench code to implement Binary-Gray Converter.
GroupB: Sequential Circuits (Tool: Vivado / ModelSim)(Any 3)
5. Write Verilog and testbench code to implement JK flip-flop and T flip-flop.
6. Write Verilog and testbench code to implement 3-bit Asynchronous counter.
7. Write Verilog and testbench code to implement 3-bit Synchronous Up and Down Counter.
8. Write Verilog and testbench code to implement Johnson/Ring Counter.
9. Write Verilog and testbench code to implement Serial in Serial out Shift Register.
Group C- Case Study
10. Group Project: Student-Selected VLSI Design Implementation

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering(2024Course)

PCC-354-ETC: Cellular Network Lab

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**TW:**25 Marks **PR:**25 Marks

Companion Course, if any: Cellular Network

Course Outcome:

CO1 Apply propagation models to analyze path loss in wireless communication systems CO2 Understand and simulate OFDM system performance.

CO3 Evaluate wireless communication link performance using link budget calculations.

CO4 Analyze cellular network performance, signal parameters, and TARA (Threat Analysis and Risk Assessment) aspects using simulation and monitoring tools.

List of Experiments

Group A: Any Three to be Performed from Exp.2 to 5 (Practical 1 is mandatory)

1. **Generate/simulate BPSK/QPSK/GMSK using MATLAB/GNU radio**
2. **MATLAB-based Path Loss Modelling for LTE and 5G Frequency Bands**

   Compute and compare the median loss by employing Hata model for various distance for carrier frequencies of 2.1 GHz and 6 GHz. Assume transmit and receive antenna heights of 40 m and 2 m in a large city. Plot the graph of path loss vs distance.

   a) Simulation of Cellular Networks using MATLAB

   b) Modelling and Evolution of Wireless Communication to 5G and beyond.

3. Ray tracing-based Channel Models for 5G using MATLAB

   a) Estimate fading channel coefficient in AWGN for given transmitted pilot symbols and received outputs across the standard Rayleigh fading wireless channel (Single Rx/Tx antenna).

4. Compute the RMS delay spread for a given Power profile and plot the graph of Power vs Delay.
5. Simulate BER performance of multi-antenna Rayleigh channel for SNR varying from 0 to 60 dB.

   a) Develop a MATLAB-based study of clustered delay line (CDL) and tapped delay line (TDL) channel models for 5G New Radio systems. Configure representative 5G fading channels and investigate how multipath delay spread, Doppler shift, antenna configuration, and propagation profile influence the time-domain and frequency-domain behavior of the wireless channel

Group B: Any Four to be Performed

6. Program to implement OFDM and evaluate frame error rate against SNR

   Indoor MIMO-OFDM Communication Link: https://www.mathworks.com/help/comm/ug/indoor-mimo-ofdm-communication-link-using-ray-tracing.html

7. Simulate and Compute minimum spacing required between the antenna for independent fading channels against operating carrier frequency bands for every generation of mobile standards.
8. Estimate channel coefficient vector Multi-Antenna Systems.

9. Compute Doppler shift of the received signal for different carrier frequency of mobile generations by considering vehicle is moving at 60 miles per hour at an angle of 30 degrees with the line joining the base station. Mobility modelling using Raytracing: https://www.mathworks.com/help/comm/ug/mobility-modeling-with-ray-tracing-channel.html
10. Perform a Link-Budget analysis for a wireless communication system
Group C: Course Project (Any 1 Group of 3 Students)
11. Measurement of Cellular Signal Strength Parameters (KPI) using **Mobile based virtual tools**, Net Monster, Network Cell Info Lite, LTE Discovery, **PC-Based Tools:** QXDM, MATLAB, GNU Radio **Mobile app G-Net Track Lite KPI Monitoring and Traffic Analysis using MATLAB - Throughput and Latency Testing.**
12. Interference and Congestion Analysis using MATLAB /GNU Radio.
13. Case study (Either one) a) **TARA** (Threat Analysis and Risk Assessment) for Cellular Network Identify possible threats, analyze vulnerabilities in the network, estimate risk levels, prioritize security measures, improve reliability and availability -**Use EXCEL for TARA** b) Cellular Coverage Analysis / **Exploring Handover Performance in Cellular Networks using MATLAB** c) Using MATLAB to create a **Network Digital Twin** for planning an urban deployment: https://www.mathworks.com/help/5g/ug/5g-network-digital-twin-in-a-3-d-urban-scenario.html
Virtual LAB Links: • https://www.vlab.co.in/participating-institute-iiit-hyderabad • https://wc-iiith.vlabs.ac.in/List%20of%20experiments.html

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement
3	Ckt/Logic Design of given problem statement
4	Diagram with theory for operation
5	Experimentation
6	Observation/ Result table
7	Graphs if any
8	Conclusions
9	Mention real life examples concerned with the respective experiments
Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.

PEC-321-ETC Program Elective 1-Courses
(Choose any One Elective from Program Elective-1 Courses)

Program Elective-I
Advanced Java Programming
Computer Networks
Digital Signal Processing
Cloud Computing

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering(2024Course)

PEC-321 (A) -ETC: Advanced Java Programming

Teaching Scheme	Credits	Examination Scheme
Theory:03Hours/Week	03	**CCE*Marks**:30Marks **End Semester (Theory):**70Marks

Prerequisite Courses, if any: Object Oriented Programming

Companion Course, if any: Advanced Java Programming Lab

Course Objectives:

To make students understand

1. Implement Java Collection Framework interfaces, classes, iterators, and sorting techniques for efficient data management.
2. Develop interactive graphical user interface (GUI) applications using Swing and JavaFX.
3. Apply Servlets, JSP, and MVC architecture principles to build dynamic web applications.
4. Utilize JDBC and Hibernate frameworks to develop database-driven Java applications.
5. Develop, test, and deploy RESTful web applications using the Spring Boot framework.

Course Outcomes:

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

CO1: Develop Java applications using Collection Framework classes, interfaces, iterators and object sorting techniques

CO2: Design and develop GUI applications using Swing, JavaFX

CO3: Apply Servlets, JSP, and MVC architecture to develop dynamic web applications.

CO4: Develop Java database applications using JDBC and Hibernate frameworks to perform CRUD operations efficiently.

CO5: Apply Spring Boot to develop simple REST APIs and test them using Postman.

Course Contents

Unit I	Collection Framework	(08 Hours)

Introduction to Collection Framework, need and advantages of Collection Framework, overview of Collection interfaces and methods. List interface using Array List and LinkedList, set interface using HashSet and TreeSet, Queue interface using Priority Queue, and Map interface using HashMap. Iteration using Iterator and basic object sorting using Comparable and Comparator interfaces.

Exemplar: Develop Java applications using Collection Framework interfaces, classes, iterators, and sorting techniques for efficient data storage and manipulation.

Mapping of Course Outcomes for Unit I

CO1: Develop Java applications using Collection Framework classes, interfaces, iterators, and object sorting techniques

Unit II	GUI Programming in Java	(08Hours)

JVM-based GUI frameworks, Swing: Introduction to SWING, Swing class hierarchy, Difference between Swing and AWT, Advantages over awt, Swing components such as JLabel, JButton, JTextField, JTable, JMenus, JScrollbar and layout managers and types.

Event Handling: Events and Event classes, event listeners, Delegation event model, mouse and keyboard events, Adapter classes **JavaFx:**Introduction to JavaFX, Java FX architecture

Exemplar : Develop interactive GUI applications using Swing and student understand modern GUI concepts such as properties and binding in JavaFX.

Mapping of Course Outcomes For Unit II

CO2: Design and develop GUI applications using Swing, JavaFX

Unit III	Java Web Development using Servlets and JSP	(09 Hours)

Java Servlets: Introduction to Servlets, Servlet Life Cycle, Creating Simple Servlets, Handling HTTP Requests and Responses, GET and POST Methods, Session Management using Cookies and Http Session.
Java Server Pages (JSP): Introduction to JSP, Difference between Servlet and JSP, JSP Directives and Implicit Objects, Expression Language (EL), Form Handling using JSP.
MVC Pattern in Web Applications: Introduction to MVC Architecture, Role of Model, View and Controller, Integration of Servlet and JSP in MVC-based Web Applications.

Exemplar : Develop a web application using Servlet and JSP to accept student details through an HTML form, process the data in Servlet, and display the submitted information using JSP.

Mapping of Course Outcomes for Unit III

CO3: Apply Servlets, JSP, and MVC architecture to develop dynamic web applications.

Unit IV	Java Database Persistence & ORM Frameworks	(09 Hours)

Introduction to JDBC: Need of JDBC, JDBC Architecture, Types of Drivers, JDBC API, Steps for Database Connectivity. JDBC Programming: Loading Driver, Establishing Connection, Statement & Prepared Statement, Result Set Handling.

JDBC CRUD Operations: Insert, Update, Delete, Select Queries, Exception Handling

Introduction to Hibernate: Hibernate Architecture, Hibernate Mapping Types, Hibernate O/R Mapping, Hibernate annotations. Hibernate Query Language

Exemplar: Develop a Hibernate-based employee management application using annotation mapping and HQL queries for CRUD operations.

Mapping of Course Outcomes for Unit IV

CO4: Develop Java database applications using JDBC and Hibernate frameworks to perform CRUD operations efficiently.

Unit V	Spring Boot: Core Concepts and REST API Development	(09Hours)

Introduction to Spring Boot: Features and Advantages, Spring Boot Architecture, Installation and Environment Setup using Maven, Creating and Running a Simple Spring Boot Application. Spring Boot Concepts: Project Structure, Dependency Management, Application Properties, Spring Boot Annotations, Spring Boot DevTools. REST API Development: Introduction to REST Architecture, Creating REST APIs using @RestController, Handling HTTP GET, POST, PUT, and DELETE Requests, Request Mapping, Path Variables, JSON Response Handling, Testing APIs using Postman.

Exemplar: Develop a simple Student Management REST API using Spring Boot to perform basic operations such as adding, viewing, and deleting student details, and test the APIs using Postman.

Mapping of Course Outcomes for Unit V

CO5: Apply Spring Boot to develop simple REST APIs and test them using Postman. implementation.

Learning Resources

Textbooks:

1. Dreamtech Press, Core and Advanced Java, Black Book, Dreamtech Press / Wiley India, 2018, ISBN-13: 9789386052216.
2. C. Bauer, G. King, and G. Gregory, Java Persistence with Hibernate, 2nd ed. Shelter Island,

NY, USA: Manning Publications, 2015.
3. H. Schildt, Java: The Complete Reference, 12th ed. New York, NY, USA: McGraw-Hill Education, 2021.
4. K. Sierra and B. Bates, Head First Java, 3rd ed. Sebastopol, CA, USA: O'Reilly Media, 2022.
5. M. Konda, Just Hibernate. Sebastopol, CA, USA: O'Reilly Media, 2013.

Reference Books:

1. Joel Murach and Michael Urban, Murach's Java Servlets and JSP, 3rd Edition, Mike Murach & Associates, 2014, ISBN-13: 9781890774783.
2. Laurentiu Spilca, Spring Start Here: Learn What You Need and Learn It Well, 1st Edition,ManningPublications, 2021, ISBN-13: 9781617298691JDBC™ API Tutorial and Reference, Third Edition, Maydene Fisher, Jon Ellis, Jonathan Bruce, Addison Wesley

MOOC/NPTEL Courses:

1. https://www.udemy.com
   Spring Boot Course: Learn Spring Boot & Build Web APIs
   Java Web Services & Java EE Microservices: JSP Servlets JBDC
   Java for Swing (GUI) Development
2. https://www.coursera.org:Advanced Java
3. https://nptel.ac.in/courses/106106220: Introduction to database system

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering(2024Course)

PEC-321(B) -ETC: Computer Networks

Teaching Scheme	Credits	Examination Scheme
Theory:03Hours/Week	03	**CCE*Marks**:30Marks **End Semester (Theory):**70Marks

Prerequisite Courses, if any: Digital Electronics

Companion Course, if any: Program Elective Course Lab 1 (PEC322ETC-B)

Course Objectives:

To make students understand

1. Fundamental concepts of computer networks and layered architecture
2. Different techniques for framing, error and flow control
3. Concepts of routing and transport mechanisms
4. Transport layer protocol performance
5. Web based networking applications

Course Outcomes:

After successful completion of the course, students will be able to:
CO1: Analyze network architecture and models
CO2: Analyze, datalink layer protocols for error and flow control
CO3: Apply IP addressing and routing techniques
CO4: Apply transport layer services and protocols.
CO5: Apply application layer protocols for network services and applications.

Course Contents

Unit I	Fundamentals of Computer networks	(09 Hours)

Data Communications, Networks, Network Topologies, Types of Computer Networks, Protocols and Standards, Design Issues for the Layers,. Network Models: The OSI Model, TCP/IP Protocol suite. Transmission Media: Guided and Unguided (Wireless). Uses of Computer Networks.

Exemplar : HDMI cable carrying audio/video signals to a TV.

Mapping of Course Outcomes for Unit I
CO1: Analyse network architecture and models.

Unit II	Data link layer	(09Hours)

Function of Data Link Layer. Design Issues: Services to Network Layer, Framing, Error Detection and Correction: Basic Concept, Linear Block Code, CRC Code, Checksum, Flow Control: Stop and Wait, Sliding Window, Error Control: Stop and Wait ARQ, Go-Back-N, ARQ, Selective Repeat ARQ, Medium Access Control: Controlled Access (Reservation, Polling, Token Passing), Random Access(ALOHA,CSMA,CSMA/CD,CSMA/CA), Link Layer Addressing: MAC Address and its Types, ARP, HDLC protocol.

Exemplar 1: Multiple users sending data through satellite channels.

Mapping of Course Outcomes for Unit II
CO2: Analyze, datalink layer protocols for error and flow control

Unit III	Network layer	(09 Hours)

Introduction to Network Layer: Network-Layer Services, Packet Switching, Forwarding of IP Packets, IPv4 addresses , Subnetting and CIDR, Network Layer Protocols: Internet Protocol (IP), ICMPv4.

Next Generation IP: IPv6 Addressing, IPv6 Protocol, Transition from IPv4 to IPV6.

Unicast & Multicast Routing: Introduction, Routing Algorithms, Unicast Routing Protocols, Introduction, Multicasting Basics, Intra-domain Multicast Protocols, Inter-domain Multicast Protocols, IGMP, Distance Vector, Link State, Path Vector, Routing in Internet: RIP, OSPF, BGP

Exemplar : Google Maps finding the best route, similar to routing in network

Mapping of Course Outcomes for Unit III

CO3: Apply IP addressing and Routing techniques

Unit IV	Transport layer	(09 Hours)

Process to process delivery, Elements of Transport Layer Protocols: Addressing, Connection establishment, Connection release, Flow control and buffering, Transmission control protocol (TCP), User Datagram Protocol (UDP), Congestion control, Quality of service (QOS), Stream Control Transmission Protocol (SCTP), Socket Programing.

Exemplar : WhatsApp voice/video calls using UDP for real-time communication

Mapping of Course Outcomes for Unit IV

CO4: Apply transport layer services and protocols

Unit V	Application layer	(09Hours)

Introduction– Principles of application layer, client-server and peer-to-peer models; World wide web (WWW), HTTP– request/response; DNS (DNS hierarchy, DNS Resource Records, DNS Name Resolution, DNS messages); Email– SMTP, MIME, POP3, IMAP, webmail, message format, FTP– basics, File transfer process; TELNET– Remote login, limitations; DHCP– Dynamic host configuration, IP allocation, Management; SNMP– Network management, monitoring.

Exemplar : Using WhatsApp, Gmail, or YouTube applications

Mapping of Course Outcomes For UnitV

CO5: Using WhatsApp, Gmail, or YouTube applications

Learning Resources

Textbooks:

1. Behrouz A. Forouzan, "Data Communications and Networking", Tata McGraw-Hill Publications, 5th Edition, 2012, ISBN: 0-07-058408-7.
2. Andrew S. Tanenbaum and David J. Wetherall, "Computer Networks", Pearson India, 5th Edition, 2012.

Reference Books:

1. James F. Kurose and Keith W. Ross, "Computer Networking: A Top-Down Approach Featuring the Internet", Pearson Education, 6th Edition, 2012, ISBN-10: 0132856204.
2. Larry L. Peterson and Bruce S. Davie, "Computer Networks: A Systems Approach", Morgan Kaufmann, 5th Edition, 2012.
3. Douglas E. Comer and M. S. Narayanan, "Computer Networks and Internets", Pearson Education, 6th Edition, 2014.
4. William Stallings, "Cryptography and Network Security: Principles and Practice", Pearson Education, 4th Edition, 2006.
5. V. K. Pachghare, "Cryptography and Information Security", PHI Learning, 3rd Edition, 2019.

e-Books

1. James F. Kurose and Keith W. Ross, *"Computer Networking: A Top-Down Approach"*, Online Resource. Link:https://people.cs.clemson.edu/~jmarty/courses/kurose/KuroseCh1-2.pdf
2. Behrouz A. Forouzan, *"Data Communications and Networking"*, Online Book. Link: http://eti2506.elimu.net/Introduction/Books/Data%20Communications%20and%20Networking%20By%20Behrouz%20A.Forouzan.pdf
3. Peter L. Dordal, *"An Introduction to Computer Networks"*, Loyola University Chicago, Online Book. Link:http://intronetworks.cs.luc.edu/current/ComputerNetworks.pdf
4. Tutorials Point, *"Data Communication and Computer Network Tutorial"*, Online Reference Material. Link:https://www.tutorialspoint.com/data_communication_computer_network/data_communication_computer_network_tutorial.pdf

MOOC/NPTELCourses:

1. NPTEL Course on: *Computer Networks*, Prof. Sujoy Ghosh, IIT Kharagpur.
   Link:https://onlinecourses.swayam2.ac.in
2. NPTEL Course on: *Introduction to Computer Networks & Internet Protocols*, Prof. Sudeb Dasgupta, IIT Roorkee.
   Link:https://onlinecourses.swayam2.ac.in
3. NPTEL Course on: *Computer Networks and Internet Protocol*, Prof. Dheeraj Sanghi, IIT Kanpur.
   Link:https://nptel.ac.in
4. NPTEL Course on: *Computer Networks*, Prof. Bhaskaran Raman, IIT Bombay.
   Link:https://nptel.ac.in/courses/106/105/106105183/

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering(2024Course)		
PEC- 321 (C) – ETC: Elective I Digital Signal Processing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory:03Hours/Week	03	**CCE*Marks**:30Marks **End Semester (Theory):**70Marks
Prerequisite Courses, if any: Signals & Systems		
Companion Course, if any: Digital Signal Processing Lab		

Course Objectives:

To make students understand

- Understand the sampling, aliasing and block schematic of digital signal processing.
- Introduction of transforms for analysis of systems using Z transform.
- Introduction of efficient transform and its application to analyze DT signals.
- Design and implementation of IIR, FIR digital filters.
- Design and implementation of 1-d and 2-D signal processing applications

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

CO1: Interpret and process discrete/ digital signals and represent DSP system.

CO2: Analyze the digital systems using the Z-transform techniques.

CO3: Implement efficient transform and its application to analyze DT signals.

CO4: Design and implement FIR and IIR filters.

CO5: Apply DSP techniques for various 1-d and 2-D signal processing applications

Course Contents		
Unit I	**DSP Preliminaries**	**(09Hours)**
Discretization of Analog Signals: Advantages of Digital over Analog signal processing Sampling theorem in time domain, recovery of analog signals, and analytical treatment with examples, mapping between analog frequencies to digital frequency, Concept of Interpolation and decimation in signal processing, Representation of signals as vectors, concept of Basis function and orthogonality, Basic elements of DSP and its requirements, Introduction to DSP processor (TMS 320 XX 6713).		
Exemplar: Analyze discrete-time signals and determine the output and representation of a Basic DSP system using signal processing techniques.		
Mapping of Course Outcomes for Unit I CO1: Interpret and process discrete/ digital signals and represent DSP system.		
Unit II	**Z-Transform**	**(09 Hours)**
Need for Z-transform, relation between Laplace transform and Z transform, relation between Fourier transform and Z transform, Concept of ROC and Properties of ROC, Relation between pole locations and time domain behavior, causality and stability considerations for LTI systems, Solution of difference equations using Z transform.		

Exemplar: Apply Z-transform techniques to analyze discrete-time signals and digital systems and determine their system response.

Mapping of Course Outcomes for Unit II

CO2: Analyze the digital systems using the Z-transform techniques.

Unit III	DFT	(09Hours)

Frequency domain sampling , DFT, Properties of DFT, circular convolution, Computation of linear convolution using circular convolution, FFT, decimation in time (DIT) and decimation in frequency(DIF) using Radix-2 FFT algorithm for 4 point and 8 point sequences, DFT & FFT computation complexity for 4 point and 8 point sequences, Linear filtering (Block convolution or Long sequence convolution) using overlap add and overlap save method.

Exemplar: Implement efficient transforms (DFT/FFT) and apply them for frequency-domain analysis of discrete-time signals.

Mapping of Course Outcomes for Unit III

CO3: Implement efficient transform and its application to analyze DT signals.

Unit IV	Digital Filter Design	(09Hours)

Concept of analog filter design.IIR filter design by impulse invariance method, Bilinear transformation method, warping effect. Butterworth filter design, Characteristics of Butterworth filters IIR filter realization using direct form, cascade form and parallel form.
Windowing techniques: Gibbs phenomenon, characteristics and comparison of different window functions, Linear phase conditions: impulse and phase and group delays, Design of linear phase FIR filter using windows: Rect, Hanning, Hamming, Blackmann& Kaiser, Magnitude and Phase response of Digital filters, Frequency response of Linear phase FIR filters, FIR filter
realization using Direct Form, Cascade and linear phase structure.

Exemplar: Design and implement IIR , FIR digital filters to meet specified frequency response requirements.

Mapping of Course Outcomes for Unit IV

CO4: Design and implement IIR, FIR filters.

Unit V	Applications of DSP	(09 Hours)

Biomedical Applications, Speech Processing, Wireless communication, IoT Applications, Image processing basics, Industry 4.0 case studies.

Exemplar: Apply DSP techniques to analyze and process 1-D and 2-D signals for real-world applications.

Mapping of Course Outcomes For Unit V

CO5: Apply DSP techniques for various 1-d and 2-D signal processing applications.

Learning Resources

Textbooks:

1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", Pearson Prentice Hall, 4th Edition.
2. Dr. Shaila Apte , "Digital Signal Processing", Wiley India Publication, 2
nd Edition.

3. S. Salivahanan, C. Gnanapriya , “Digital Signal Processing”, McGraw Hill, 2nd Edition.
Reference Books: 1. Ifeachor E.C, Jervis B. W, “Digital Signal Processing: Practical approach”, Pearson Publication, 2nd Edition. 2. Li Tan , “Digital Signal Processing : Fundamentals and Applications”, Academic Press, 3rd Edition. 3. Schaum's Outline of “Theory and Problems of Digital Signal Processing”, 2nd Edition. 4. Oppenheim, Schafer , “Discrete-time Signal Processing”, Pearson Education, 1st Edition. 5. K.A. Navas, R. Jayadevan , “Lab Primer through MATLAB”, PHI, Eastern Economy Edition.
MOOC/NPTEL Courses: 1. NPTEL Course on “Digital Signal Processing” Link of the Course: https://nptel.ac.in/courses/117/102/117102060/ 2. NPTEL Course on “Digital Signal Processing” Link of the Course: https://nptel.ac.in/courses/108/105/108105055

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024Course)

PEC-321 (D) -ETC: Cloud Computing

Teaching Scheme	Credits	Examination Scheme
Theory :03 Hours/Week	03	**CCE* Marks:** 30 Marks **End Semester (Theory) :**70 Marks

Prerequisite Courses, if any:

Companion Course, if any: **PEC-322-ETC: Elective 1 Lab (Cloud Computing)**

Course Objectives:

To make students understand

1. The fundamental knowledge of Cloud Computing architecture, deployment models and service models.
2. Virtualization technologies and their role in cloud computing environments.
3. Cloud computing architecture, SOA principles and cloud security mechanisms.
4. The concepts, architectures and types of cloud storage systems.
5. Application deployment strategies on cloud platform.

Course Outcomes:

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

CO1: Describe the fundamentals, architecture, deployment models and service models of Cloud Computing.

CO2: Explain the concept of virtualization, virtualization architectures, virtual machines and hypervisors used in cloud computing environments.

CO3: Analyze the characteristics, principals and components of service-oriented architecture and its integration with cloud computing environments.

CO4: Categorize cloud storage concepts related to storage models, storage services, data management techniques, security mechanisms used in cloud storage systems.

CO5: Apply cloud native design principles, modern deployment strategies, and orchestration tools to deploy, scale and manage automated applications across cloud infrastructure services.

Course Contents

Unit I	Fundamentals of Cloud Computing with Cloud Service Models	(09 Hours)

Introduction to Cloud Computing, History and Evolution of Cloud Computing, Characteristics of Cloud Computing, Benefits and Applications of Cloud Computing, Advantages and Disadvantages of Cloud Computing Exploring the Cloud Computing Stack, Cloud Types and Models: NIST Model, Cloud Cube Model, Cloud Deployment Models, Introduction to Cloud Services and their Benefits, Cloud Service Models and their Characteristics, Applications and Comparison of Cloud Services including Software as a Service (SaaS) Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Network as a Service (NaaS), Identity as a Service (IDaaS) and Database as a Service (DBaaS).

Exemplar: Google Drive, Amazon Web Services, Netflix, Zoom, Google Classroom, Dropbox, Facebook outage, Google Cloud, VMWare, Microsoft Azure, Iaas: Amazon EC2, Paas: Heroku, Saas: Google Workspace, Naas: Cisco, IDaas: Okta, Daas: MongoDB Atlas.

Mapping of Course Outcomes for Unit I

CO1: Describe the fundamentals, architecture, deployment models and service models of cloud computing.

Unit II	Virtualization	(09 Hours)

Introduction to Virtualization and its role in Modern Computing Environments, Architecture and Types of Virtualization Architectures: Bare Metal and Hosted, Virtual Machine (VM), Properties of VM, Type-1, Type-2 Hypervisors, Best Practices for Hypervisor Security, Types of Virtualization including Hardware, Software, Operating System, Server and Storage Virtualization, Methods of implementing Storage Virtualization, Network Virtualization Types and Techniques, Advantages and Limitations of Virtualization, Virtualization Architecture and Virtualization Software, Applications of Virtualization in Cloud Computing, Data center , Server Consolidation, Resource Optimization and Disaster Recovery, Introduction to Containerization with Docker. Comparison between Virtualization and containerization.		
Exemplar: Xen, KVM, VMware, Virtual Box, Cloud server in Microsoft Azure, Multiple Docker Containers, Storage Area Network (SAN), Microsoft Hyper-V. OVirt-Management Tool for Virtualization Environment.		
Mapping of Course Outcomes for Unit II CO2: Explain the concept of virtualization, virtualization architectures, virtual machines and hypervisors used in cloud computing environments.		
Unit III	**Service Oriented Architecture and Cloud Security**	**(09 Hours)**
Cloud Computing Architecture (CCA), Design Principles and Architectural Components of Cloud Systems, Cloud Computing Life Cycle (CCLC), Cloud Deployment and Service Management Phases, Cloud Computing Reference Architecture and its Functional Layers, Service Oriented Architecture (SOA), characteristics, Principles and Fundamental Components of SOA, Integration of SOA with Cloud Environments. Cloud Security Concepts and Requirements, Cloud CIA Security Model including Confidentiality, Integrity and Availability, Cloud Computing Security Architecture, Security Management in Cloud Environments, Service Provider Security issues and Compliance Challenges, Cloud Security Issues and Threats, Virtualization Security Concerns, Host Security Mechanisms, Data Security, Privacy Protection Techniques, Network Security, Access Control, Authentication Methods and Firewall Technologies in Cloud Computing.		
Exemplar: Online Storage Services: Google Drive, Video Streaming: Netflix, Digital Payment: PayPal, Online Banking, Educational Platform: Google Classroom, Microsoft Teams, VMware, Hyper-V, Social Networking Platform.		
Mapping of Course Outcomes for Unit III CO3: Analyze the characteristics, principals and components of service-oriented architecture and its integration with cloud computing environments.		
Unit IV	**Cloud Storage Solutions**	**(09 Hours)**
Introduction to Cloud Storage: Overview, Need, Advantages, Traditional Storage vs Cloud Storage, Types of Cloud Storage: Object Storage, Block Storage, File Storage, Cloud Storage Architecture: Storage Virtualization, Data Replication, Scalability, Cloud Storage Services. Object Storage, Block Storage, File Storage in Amazon Web Services (AWS), Google Cloud (GCP) and Microsoft Azure. Data Management in Cloud Storage: Data Backup and Recovery, File Synchronization, Version Control. Security in Cloud Storage: Data Encryption, Access Control, Authentication and Authorization, Performance and Cost Optimization: Storage Performance, Cost Models, Monitoring Techniques, Applications of Cloud Storage: Enterprise Storage, IoT Storage, Educational and Healthcare Applications.		
Exemplar: Amazon S3, Google Cloud Storage, Azure Blob Storage, Dropbox, Google Drive, Object Storage, Block Storage, File Storage, Storage Virtualization, Backup and Recovery, Data Encryption, Access Control, Storage Synchronization, Archive Storage, Cloud Storage Security.		
Mapping of Course Outcomes for Unit IV CO4: Categorize cloud storage concepts related to storage models, storage services, data management techniques, security mechanisms used in cloud storage systems.		
Unit V	**Cloud Platforms, Services and Application Deployment**	**(09 Hours)**

Core Cloud Infrastructure Services: Compute services (Virtual Machines, Serverless/Function as a Service), Network Services (Virtual Private Clouds, Load Balancers, Content Delivery Networks), and Managed Database Services.
Cloud-Native Concepts and Applications: Microservices Architecture vs. Monolithic Architecture, Serverless Computing Paradigm, Cloud Native Application Design Principles (The Twelve Factor App).
Application Deployment Methodologies: Comparison between Traditional Deployment and Cloud Deployment, Deployment Models: Blue-Green Deployment, Canary Deployment, Rolling Updates, Infrastructure as Code (IaC) Concepts and Benefits.
Cloud Deployment Tools and Orchestration: Introduction to Container Orchestration using Kubernetes, Deployment Automation using CI/CD (Continuous Integration/Continuous Deployment) Pipelines in the Cloud, Cloud Monitoring, Logging and Auto Scaling Mechanics.

Exemplar: Amazon EC2, Azure Virtual Machines, AWS Lambda, Azure Functions, Amazon VPC, AWS Elastic Load Balancing (ELB), Amazon CloudFront (CDN), Amazon RDS, MongoDB Atlas.
Kubernetes (EKS/GKE), Terraform, AWS CloudFormation, GitHub Actions, AWS Code Pipeline, Jenkins. Amazon CloudWatch, Prometheus, Grafana.

Mapping of Course Outcomes for Unit V
CO5: Apply cloud native design principles, modern deployment strategies, and orchestration tools to deploy, scale, and manage automated applications across cloud infrastructure services.

Learning Resources

Textbooks:
1. Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Dr. Deven Shah, "Cloud Computing: Black Book", Dream Tech, New Delhi, 2016, ISBN: 978-93-5119-418-7.
2. Surbhi Rastogi, "Cloud Computing Simplified", BPB Publications, 2021, ISBN-13: 978-9390684359.
3. Buyya, Rajkumar, Christian Vecchiola, and S. Thamarai Selvi, "Mastering Cloud Computing: Foundations and Applications Programming", Newnes, 2013, ISBN: 978-0-12-411454-8.

Reference Books:
1. Kamal Kant Hiran, et al., "Cloud Computing: Master the Concepts, Architecture and Applications with Real-World Examples and Case Studies", BPB Publication, 2019, ISBN: 978-93-88511-407.
2. Judith Hurwitz, "Cloud Computing for Dummies", Wiley India, 2011, ISBN: 978-81-265-2487-7.
3. A. Srinavasan, J. Suresh, "Cloud Computing: A Practical Approach for Learning and Implementation", Pearson, 2014, ISBN:978-81-317-7651-3.
4. Anthony T. Velte, Toby J. Velte, Robert Elsenpeter, "Cloud Computing: A Practical Approach", The McGraw-Hill, 2010, ISBN: 978-0-07-162695-8.
5. Barrie Sosinsky, "Cloud Computing Bible", Wiley Publications, 2010, ISBN: 978-81-265-2980-3.

Online Resources:
1. https://docs.aws.amazon.com/
2. https://docs.cloud.google.com/docs/compute-area
3. https://learn.microsoft.com/en-us/
4. https://kubernetes.io/docs/setup/
5. https://www.cloudflare.com/learning/cdn/what-is-a-cdn/
6. https://docs.docker.com/

MOOC / NPTEL Courses:
1. NPTEL Course on Cloud Computing https://nptel.ac.in/courses/106105167
2. Cloud Computing and Distributed Systems, IIT Patna by Prof. Rajiv Misra https://nptel.ac.in/courses/106104182
3. Cloud Computing, IIT Kharagpur, by Prof Soumya Kanti Ghosh https://nptel.ac.in/courses/106105167

OR

4. Eduskill AWS Academy: Cloud Foundation

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024Course)

PEC- 322 (A)- ETC: Advanced Java Programming Lab

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**Term Work:** 50

Companion Course, if any: **Advanced Java Programming**

Course Objectives:

To make students understand

1. To familiarize students with advanced Java programming concepts, Collection Framework, GUI development, event handling, and JavaFX for building interactive desktop applications.
2. To develop the ability to design and implement database-driven and web-based applications using Servlets, JSP, JDBC, Hibernate, and related enterprise Java technologies.
3. To enable students to create enterprise-level solutions using Spring Boot, REST APIs, and modern Java frameworks for solving real-world software development problems.

Course Outcome: Learner will be able to

CO1: Apply Java Collection Framework, GUI components, event handling mechanisms, and JavaFX features to develop interactive desktop applications.

CO2: Develop database-driven and web-based applications using Servlets, JSP, JDBC, Hibernate, and related enterprise Java technologies.

CO3: Design and implement RESTful and full-stack Java applications using Spring Boot, modern frameworks, and database integration to address real-world requirements.

List of Experiments

Perform Any 9 from 1 to 15 and Mini Project Compulsory

1. Develop a Java program to store student information using ArrayList and perform operations such as insertion, deletion, searching, updating, and traversal using Iterator.
2. To implement Set interface for duplicate removal and sorting, and Queue interface using PriorityQueue for task processing.
3. Develop a Java program to create a student database using HashMap. Store roll number and student name as key-value pairs and traverse the records using Iterator. Create a Student class and sort student records by roll number using Comparable and by name using Comparator.
4. Develop a GUI which accepts the information regarding the marks for all the subjects of a student in the examination. Display the result for a student in a separate window.
5. Write a program to create a frame using Swing. Implement mouse Clicked, mouse Entered() and Mouse Exited() events. The frame should become visible when the mouse enters it
6. Design a Simple JavaFX Form demonstrating: Text Field input, Button click event, Binding of Text Field text property to Label
7. Develop a JSP-based Employee Information application to collect employee details and display the entered information using JSP implicit objects and Expression Language (EL).
8. Create a simple calculator application using servlet.
9. Create a login form and implement state management using Cookies and HttpSession in a Java web application.
10. Develop a Java program using JDBC to perform insert, update, delete, and display operations

on a student database table.
11. Develop program to Execute HQL Queries for Data Retrieval
12. Develop Annotation-Based Student Management System
13.Create a simple Spring Boot application to display a welcome message and demonstrate project execution using Maven.
14. Create a simple REST API using Spring Boot to display student information and test the API using Postman.
15.Create a Spring Boot application to accept student details and display the information using REST API and JSON response.
16. Mini Project
Virtual LAB Links: 1. https://java-iitd.vlabs.ac.in/

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering(2024Course)

PEC-322-ETC-(B): Computer networks Lab

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**Term Work** :50

Prerequisite Courses: Digital Electronics.

Companion Course, if any: Program Elective Course1(PEC321ETC-B)

Course Objectives: To make students to apply

1)Fundamentals of computer networks, networking devices, and routing protocols

2) Configuration and simulation of network services, servers, and communication protocols

3) Develop networks for specific applications and real-world requirements

Course Outcomes:

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

CO1: Analyze computer networks using networking devices, routing protocols, network utilities, and packet analysis tools

CO2: Simulate network services, servers, and protocols, and analyze network communication using simulation and packet analysis tools

CO3: Develop a network for certain application

List of Experiments

Group A: Any four to be Performed

1. Implementation of LAN using suitable multiuser windows operating system and demonstrating client-server and peer to peer mode of configuration.
2. Learn MAC Address with switch using network Simulator.
3. Simulate various Networks (LAN, WAN) using relevant network devices on simulator and use network commands a) Ping b) Ipconfig c) Netstat d)Tracert/Traceroute/ Tracepath e) NSlookup.
4. Configure router using RIP /BGP, using a Network Simulator (e.g., packet tracer).
5. Illustrate the details of the live type of traffic (ARP, Frame analysis, ethernet) from interface using packet capture and analysis tool.

Group B: (Any three to be Performed)

6. Simulate leaky bucket/token bucket.
7. Execute Telnet, DHCP Server using a simulator.
8. Capture packets in LAN and observe the working of protocols using PING / TRACEROUTE / PATHPING.
9. Execute Proxy, web Server using simulator.
10. Configure servers like HTTP / FTP and understand packet sequence and data flowing between client-servers using packet analysis tools.

Group C: Course Project (Anyone to be performed)

11. Project: Build a network and perform traffic analysis using wire shark
12. Project: Wi-fi based home automation using IOT

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement
3	Ckt/Logic Design of given problem statement
4	Diagram with theory for operation
5	Experimentation
6	Observation/ Result table
7	Conclusions
8	Mention real life examples concerned with the respective experiments
Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering(2024Course)		
PEC-322 (C) – ETC: Digital Signal Processing Lab		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical:02Hours/Week	01	**Term Work**: 50 Marks
Companion Course, if any: Digital Signal Processing		

List of Experiments

Group A: All compulsory
CO1: Apply DSP concepts and techniques to analyze discrete-time signals and systems using sampling theory, Z-transform, DFT/IDFT, convolution methods, and FIR/IIR filter realization structures through simulation and implementation tools.
1. Verify the sampling theorem and aliasing effects with various sampling frequencies. Also implement the sampling theorem using VLAB.
2. Find the z-transform of a given difference equation, compute its pole zero plot and comment on its stability.
3. Compute DFT and IDFT for a 4 point sequence using N=4 and N= 8 (using zero padding)
4. Find N-point circular convolution using formula and verify its results. Implement linear filtering using circular convolution
5. Implement IIR structures using Direct form I/ II/ Cascade form. Implement FIR structures using Direct Form/Cascade/Linear phase structures.
Group B: Any Three to be Performed
CO2: Design, implement, and evaluate FIR and IIR digital filters using transformation techniques, window methods, FFT-based analysis, and efficient filtering algorithms for discrete-time signal processing applications.
6. Design a Butterworth filter using Bilinear Transformation, for given specifications (passband gain and pass band edge frequency, stopband attenuation and stop band edge frequencies OR order of the filter, passband range and sampling frequency)
7. Design the symmetric FIR low pass filter for which desired frequency response is expressed as Hd (w)={(e^(-jwτfor|w|≤ wc) and 0 elsewhere The length of the filter should be M = 7 and Wc=1 radians/sample. Make use of the Rectangular/ Hamming/ Hanning/Blackman/ Kaiser window
8. Implementation of High Pass FIR or IIR filter for a given sequence
9. Compute the DFT by writing a function for a long sequence (of length 32 or above). Calculate the computational complexity. Compare the time required by DFT & FFT functions.
10. Implement the linear filtering using Overlap Add or Overlap Save method.
Group C: Course Project (Any 1Group of 3 Students)
CO3: Apply DSP techniques to analyze speech signals, perform multirate processing, and implement image compression applications.

11.Find the pitch frequency of given speech signal
12. Generate a signal as addition of two or more different frequencies sinusoidal signal. Decimate and interpolate it by the given factor. Plot the input and output signals.
13.Implement image compression using DCT and calculate the compression ratio.
Virtual LAB Links: Link of the Virtual Lab: http://vlabs.iitkgp.ernet.in/dsp/#

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024 Course)		
PEC-322 (D) -ETC: Cloud Computing Lab		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 02 Hours/Week	01	**Term Work:** 50 Marks
Companion Course, if any: PEC-321-ETC: Program Elective 1 (Cloud Computing)		

Course Objectives:

To make students capable to

1. **Illustrate** the deployment of basic cloud-based applications using cloud platforms such as Google App Engine, Cloud Sim, AWS, Microsoft Azure, and Open Stack.
2. **Implement** cloud deployment applications using Google Colab and Google Earth Engine.
3. **Design** cloud storage, backup, disaster recovery, and virtual machine management techniques for reliable cloud-based services.

Course Outcomes:

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

CO1**:** **Explain** the cloud applications, virtual machines and cloud runtime telemetry metrics.

CO2: **Evaluate** cloud-based storage, backup, recovery, and disaster management solutions

CO3: **Describe** cloud architecture solutions, security models and private cloud case studies for enterprise applications.

List of Experiments

Group A: Any Three to be Performed
1. Use GAE launcher to launch the web applications.
2. Simulate a cloud scenario using Cloud Sim and run a scheduling algorithm.
3. Find a procedure to launch virtual machine using try stack (Online Open stack Demo Version).
4. Find a procedure to transfer the files from one virtual machine to another virtual Machine.
5. Analyze performance differences between virtualization and containerization.
6. To simulate and analyze system behavior, response times, and machine activation during sudden load spikes in traditional versus elastic cloud systems using Google Colab or CloudSim.
7. To capture, analyze and visualize the performance metrics of the Google Colab environment for any simulation or code. Record runtime telemetry tracking: CPU utilization, memory consumption, execution speed and system cost metrics.
Group B: Any Two to be Performed

8. Create an S3 bucket using Amazon Web Services or blob storage using Microsoft Azure and upload files to the cloud storage service.
9. Implement data backup and recovery mechanisms using Amazon Web Services S3 cloud storage services.
10. Design backup and recovery strategy for virtual machine in cloud deployed application during disaster events.
11. To Perform Spatiotemporal Analysis of any one use case using Google Earth Engine as cloud platform.
10. Integrated cloud based spatiotemporal analysis and predictive modelling using Google Earth Engine/ Google Colab.
Group C: Course Case Study/Project (Any 1 Group of 3 Students)
12. Case Study: Tools for Building Private Cloud/ Instance Creation in Cloud Environment.
13. Case Study: Data Storage Security in Private Cloud /Ubiquitous based on Cloud/ Cloud Computing Security Architecture for Enterprise Cloud.
14. Poster Presentation: Cloud Architecture for any one Enterprise Solution.
Online Resources: 1. https://docs.aws.amazon.com/ 2. https://docs.cloud.google.com/docs/compute-area 3. https://learn.microsoft.com/en-us/ 4. https://kubernetes.io/docs/setup/ 5. https://www.cloudflare.com/learning/cdn/what-is-a-cdn/ 6. https://docs.docker.com/
MOOC / NPTEL Courses: • NPTEL Course on Cloud Computing https://nptel.ac.in/courses/106105167 • Cloud Computing and Distributed Systems, IIT Patna by Prof. Rajiv Misra https://nptel.ac.in/courses/106104182 • Cloud Computing, IIT Kharagpur, by Prof Soumya Kanti Ghosh https://nptel.ac.in/courses/106105167 OR Eduskill AWS Academy: Cloud Foundation

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement
3	Logic Design of given problem statement
4	Logic diagram with IC number pin connections
5	Observation table / Truth table
6	Timing diagram
7	Result table
8	Conclusions
9	Mention real life examples concerned with the respective experiments

Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.

Savitribai Phule Pune University ThirdYearofElectronicsandTelecommunicationEngineering(2024Course)		
MDM-331-ETC: Machine Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Tut:02Hours/Week **Practical:**02Hours/Week	**Tut**:02 **Practical:** 01	**Termwork**:25Marks **Oral:**25Marks

Prerequisite Courses, if any: Engineering Mathematics
(Linear Algebra, Probability & Statistics, Calculus), Digital signal processing, Data Structures and Algorithms

Companion Course, if any:

Course Objectives:

To make students understand

1. To introduce the fundamentals of Artificial Intelligence, Machine Learning, and data-driven systems.
2. To develop students' ability to preprocess, analyze, and visualize engineering datasets.
3. To enable students to implement Machine Learning algorithms using Python-based tools.
4. Introduce emerging technologies such as Edge AI, TinyML, AIoT, and Generative AI.
5. Prepare students for industry-oriented AI projects, internships, research, and multidisciplinary applications.

Course Outcomes:

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

CO1: Explain Machine Learning fundamentals, workflow and AI applications in Electronics and Telecommunication Engineering.
CO2: Apply data preprocessing, visualization, and exploratory analysis techniques using Python libraries.
CO3: Implement Supervised Machine Learning Algorithms for predication and classification problems.
CO4: Apply Unsupervised learning techniques and Analyze engineering datasets using clustering approaches.
CO5: Develop AI base mini-projects using modern tools, real-world datasets and emerging AI technologies.

Course Contents		
Unit I	**Introduction to Artificial Intelligence and Machine Learning**	**Tut:1,2,3,4**
Introduction to Artificial Intelligence, Machine Learning, and Deep Learning, Applications of Machine Learning in: Electronics and Telecommunication Engineering: Signal Processing, Smart Communication Systems, Healthcare, IoT and Smart Devices, Industrial Automation, Types of Machine Learning: Supervised Learning, Unsupervised Learning, Reinforcement Learning (Overview), Machine Learning Workflow: Data Collection, Data Preprocessing, Model Training, Model Evaluation, Deployment, Introduction to Python Ecosystem: NumPy, Pandas, Matplotlib, Scikit-learn, Google Colab, Emerging Trends: Generative AI, AI Assistants, Edge AI, TinyML, AIoT, AI in 5G/6G Systems		

Case Studies (Anyone): AI applications in Smart Phones, Recommendation Systems, AI-enabled Communication Systems, Generative AI applications.

Mapping of Course Outcomes for Unit I

CO1: **Explain** Machine Learning fundamentals, workflow and AI applications in Electronics and Telecommunication Engineering.

Unit II	Data Preprocessing and Exploratory Data Analysis	Tut:5,6,7

Introduction to datasets and dataset formats, Open-source datasets and data collection methods, Data Preprocessing Techniques: Handling missing values, Data cleaning, Feature selection, Feature scaling, Data normalization, Standardization, Training and Testing datasets, Exploratory Data Analysis (EDA): Statistical analysis, Correlation analysis, Histograms, Scatter plots, Heat maps, Data visualization techniques, Introduction to Responsible AI and bias in datasets.

Case Studies (Any One): Telecom Traffic Dataset Analysis, IoT Sensor Data Analysis, Student Performance Dataset Visualization.

Mapping of Course Outcomes for Unit II

CO2: **Apply** data preprocessing, visualization, and exploratory analysis techniques using Python libraries.

Unit III	Supervised Machine Learning Techniques	Tut:8,9,10

Introduction to Supervised Learning, Regression Techniques: Linear Regression, Multiple Linear Regression, Classification Techniques: Logistic Regression, K-Nearest Neighbors (KNN), Decision Tree, Random Forest, Model Evaluation Metrics: Accuracy, Precision, Recall, F1 Score, Confusion Matrix, Concept of Cross Validation, Applications in: Signal Classification, Predictive Maintenance, Medical Diagnosis, Spam Detection, Network Traffic Analysis.

Case Studies (Anyone): House Price Prediction, Email Spam Classification, Predictive Maintenance in Industry, Signal Classification System.

Mapping of Course Outcomes for Unit III

CO3: **Implement** Supervised Machine Learning Algorithms for predication and classification problems.

Unit IV	Unsupervised Learning and Emerging AI Concepts	Tut:11,12,13

Introduction to Unsupervised Learning, Clustering Techniques: K-Means Clustering, Hierarchical Clustering (Overview), Dimensionality Reduction: PCA (Overview), Anomaly Detection Concepts, Introduction to Neural Networks and Deep Learning, Overview of: Edge AI, TinyML, Explainable AI (XAI), AI in Embedded Systems, AI in Cyber security, Applications in: Smart Healthcare, Image Processing, Autonomous Systems, Smart Agriculture, Industrial Automation.

Case Studies (Anyone): Customer Segmentation using K-Means, Smart Healthcare Monitoring, AI-based Traffic Analysis, AI-enabled Embedded System.

Mapping of Course Outcomes for Unit IV

CO4: **Apply** Unsupervised learning techniques and Analyze engineering datasets using clustering approaches.

Unit V	Industry-Oriented AI Applications and Mini Project	Tut:14,15,16

AI Project Development Cycle, Working with Real-world Datasets: Kaggle datasets, GitHub, repositories, Open-source AI resources, Introduction to: AI APIs, Cloud AI tools, Generative AI tools, Prompt Engineering Basics, AI Ethics and Responsible AI, Industry Applications: AI in Telecommunication, AI in IoT, AI in Robotics, AI in Smart Manufacturing, AI in Healthcare.

Case Studies (Anyone): AI-based Chat bot Demonstration, Smart Attendance Prediction System, AI-enabled IoT Monitoring System, AI-based Signal Analytics.

Mapping of Course Outcomes for UnitV

CO5: **Develop** AI base mini-projects using modern tools, real-world datasets and emerging AI technologies.

List of Suggested Mini Projects (Not limited to following topics)

1. Smart Attendance Prediction System
2. Telecom Traffic Analysis
3. ECG Signal Classification
4. Predictive Maintenance System
5. Smart Agriculture Monitoring
6. AI-based Image Classification
7. IoT Sensor Data Analytics
8. Voice Command Recognition
9. AI Chatbot using ML APIs
10. Smart Communication Network Analysis

Suggested Software and Tools

- Python
- Google Colab
- Jupyter Notebook
- Scikit-learn
- Tensor Flow/Keras
- Kaggle
- GitHub
- Power BI/Tableau (Optional)

Industry-Oriented Components

- Use of Kaggle datasets
- Exposure to Git Hubre positories
- AI model demonstrations
- Mini Hackathon/AI Challenge
- Technical presentation and report writing
- Exposure to Generative AI tools and APIs
- Industry dataset analysis

Expected Skill Development

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

- Work with real-world datasets
- Develop and evaluate Machine Learning models
- Apply AI concepts to Electronics and Telecommunication applications

- Understand emerging AI technologies
- Participate in internships, hackathons , and AI competitions
- Prepare for higher studies and industry roles in AI/ML domains

Learning Resources

Textbooks:

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras and Tensor Flow,O'Reilly Publications.
2. Ethem Al paydin, Introduction to Machine Learning, MIT Press.
3. Andreas Müller and Sarah Guido, Introduction to Machine Learning with Python, O'Reilly Publications.

Reference Books:

1. Tom M. Mitchell, Machine Learning, McGraw Hill Education.
2. Ian Good fellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press.
3. Christopher Bishop,Pattern Recognition and Machine Learning, Springer.

MOOC/NPTELCourses:

1. NPTEL–Introduction to Machine Learning
2. Machine Learning by AndrewNg–Coursera
3. Math Works Machine Learning Onramp
4. Google AI Courses
5. Kaggle Micro Courses

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering(2024Course)		
MDM-331-ETC: Machine learning Lab		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical :02 Hours/Week **Tutorial :**02 Hours/Week	01	**TermWork**:25 **Oral:** 25Marks
Companion Course, if any:		
List of Experiments		
Group A: Any Eight to be Performed		
1. Perform installation and familiarization of Python programming environment using Google Colab.		
2. Visualize engineering datasets using graphs, histograms, and scatter plots with Matplotlib.		
3.Perform data preprocessing and cleaning operations on real-world datasets.		
4. Apply feature scaling, normalization, and standardization techniques using Python tools.		
5. Implement Linear Regression algorithm for prediction of engineering parameters.		
6. Develop classification models using Logistic Regression for real-world datasets.		
7. Implement K-Means clustering algorithm for grouping and pattern analysis of datasets.		
8. Demonstrate dimensionality reduction using Principal Component Analysis (PCA).		
9. Explore AI APIs and cloud-based AI tools for Machine Learning applications.		
10. Develop and implement a mini-project using Machine Learning techniques and real-world datasets.		

Savitribai Phule Pune University
Third Year of Electronics & Telecommunications Engineering (2024Course)

ELC-342-ETC: Technical Seminar

Teaching/scheme	Credits	Examination Scheme
Practical: #02Hours/Week	01	**Oral :**25Marks

The "Technical Seminar" course is a critical milestone designed to bridge the gap between structured classroom learning and independent research. It prepares students for their Final Year Projects by cultivating literature retrieval, critical analysis, and technical communication skills.

Course Objectives:

The course aims to:

1. To develop research orientation and technical communication skills in emerging Computer Engineering and Artificial Intelligence domains.
2. To enable students to critically review, analyze, and synthesize contemporary research papers, white papers, patents, and technical standards.
3. To promote interdisciplinary thinking aligned with NEP-2020 multidisciplinary philosophy.
4. To inculcate ethical awareness, sustainability perspective, and societal impact analysis of AI systems.
5. To prepare students for industry, higher education, entrepreneurship, and innovation ecosystems.

Course Outcomes:

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

CO1: Identify and select emerging and relevant technical topics through literature survey.
CO2: Analyze and synthesize information from research papers, journals, and credible sources.
CO3: Demonstrate effective technical communication skills through oral presentation.
CO4: Prepare a structured technical report following academic writing standards.
CO5: Use modern tools (presentation software, plagiarism checkers, referencing tools) for seminar preparation

Guidelines for Conduct of Technical Seminar

The Technical Seminar shall be research-oriented and domain-specific, focusing strictly on recent development in E&TC Engineering, IoT .

Guidelines for Technical Seminar

- Topic must be from emerging Computer Engineering, Artificial Intelligence and Data Science domains (preferably last 3–5 years).
- Must involve a minimum of 5 recent research papers (IEEE, ACM, Elsevier, Springer etc).
- Student should be summarizing paper – Reading abstracts and finding ideas, conclusion, advantages of their approaches and the drawbacks of the papers. They should understand the results from a research paper to related research problems. comparing the approach - Identify weaknesses and strengths in recent research articles in the subject.
- Practical sessions on how to read, analyze and summarize research papers should be arranged.
- Should not be a basic textbook topic.

- Must include: Problem statement, State-of-the-art analysis, Comparative study, Ethical & societal impact, Interdisciplinary themes aligned with NEP encouraged.
- Topic should be approval by a faculty panel/ Seminar coordinator/ Head of the department.

Seminar Process

- Orientation, Topic Finalization and Guide allocation (Week 1–2)
  - Conduct an orientation session explaining: Objectives of the technical seminar, Evaluation criteria and expected outcomes
  - Each student must submit: Title of the seminar, Problem statement, Relevance to current technology trends, Approval by guide is mandatory before proceeding
  - Students are assigned a faculty guide based on specialization alignment (e.g., AI/ML, Cyber security, Cloud Computing, IoT). Students identify 2–3 broad domain so interest.
  - The precise topic is finalized and approved by a departmental seminar committee.
- Literature Survey & Problem Understanding (Week 2–4)
  - Students must: Refer minimum 5–8 recent research papers (IEEE, Springer, Elsevier, ACMetc.)
  - Use scholarly databases like IEEE Xplore , Google Scholar, Science Direct.
  - Prepare a literature survey matrix, including:
    - Author/year
    - Methodology used
    - Keyfindings
    - Limitations
  - Identify: Research gaps and Challenges in existing approaches.
- Synopsis Preparation & Presentation (Week 4–5)
  - Submit a 2–3page synopsis including Introduction, Literature insights, Objectives, Proposed seminar scope.
  - Conduct a Synopsis Presentation (5–7 minutes): Evaluate clarity of understanding, Receive feedback for improvement.
  - Approval required before proceeding to full report.
- In-depth Study & Content Development (Week 5–8)
  - Students should: Deeply analyze concepts, models, architectures ,or case studies, Include diagrams, flowcharts, and comparative tables.
- Weekly review meetings with guide: Track progress, Ensure conceptual clarity, Emphasis on: Critical analysis (not just description), Real-world applications.

- Draft Report Submission & Review (Week 8–10)
  - Submit first draft of the report
  - Guide provides feedback on: Technical content quality, Structure and coherence, Referencing and plagiarism, Students must revise based on suggestions by the guide.
- Pre-Seminar Presentation (Mock Evaluation) (Week 10–11)
  - Conduct a mock presentation simulating final evaluation.
  - Focus on: Presentation skills, Time management, Handling questions.
  - Peer and faculty feedback should be incorporated.
- Final Report Submission (Week 11–12)
  - Submit: Final hardcopy (if required), Softcopy (PDF format)
  - Ensure: Proper formatting, Plagiarism compliance (<20%), Correct referencing using reference managers like Zotero and Mendeley Desktop.
- Final Seminar Presentation & Viva Voce (Week 12–13)
  - Presentation duration:10–15 minutes, followed by Q&A session (5–10 minutes) Evaluation based on: Depth of understanding, Analytical ability, Communication skill

Method of Evaluation

- During the seminar session each student is expected to prepare and present a topic on engineering/ technology, for duration of about 12to 15 minutes.
- Each student is expected to present at least twice during these semesters and the student is evaluated based on that.
- At the end of the semester, he / she can submit a report on his / her topic of seminar and marks are given based on the report.
- A Faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance.

Seminar Report

The final technical report should be highly structured (20 to 25 pages) , strictly technical, and clear of marketing jargon. The recommended structure includes

•Cover Page & Certificates: Standard institutional format.

•Abstract: A single, dense paragraph (200–250 words) capturing the domain background, problem identified, state-of-the-art solutions analyzed, and key takeaways.

•Chapter 1: Introduction: Overview of the technology, historical context, motivation, and scope.

•Chapter 2: Literature Survey: A comprehensive critical analysis of the referred papers. It is highly recommended to synthesize this into a structured matrix, tabular form

•Chapter 3: System Architecture / Technical Core: Detailed breakdown of algorithms, mathematical formulations, protocols, or structural pipelines.

Chapter 4: Comparative Analysis / Applications: Deep dive into current real-world deployment challenges, performance metrics (latency, accuracy, scale), and limitations.

•Chapter 5: Conclusion & Future Scope: Summarizing the insights gleaned and highlighting concrete pathways for prospective final-year project extensions.

References: Strictly formatted in standard IEEE.

Learning Resources

1. Raman,M.,&Sharma,S.(2015).TechnicalCommunication:PrinciplesandPractice(3rded.). Oxford University Press.
2. Kothari,C.R.(2014).ResearchMethodology:MethodsandTechniques(3rded.).NewAge International Publishers.

Savitribai Phule Pune University,Pune

Maharashtra, India

TE - Electronics and Telecommunication Engineering

2024 Pattern

Semester VI

With effect from AcademicYear2026–27

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024Course)		
PCC-351-ETC: Embedded System Design		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory:03Hours/Week	03	**CCE*Marks:**30Marks **End Semester (Theory):** 70Marks
Prerequisite Courses, if any: Microcontroller and Applications		
Companion Course, if any: Embedded System Design Lab		

Course Objectives:

To make students understand

1. Analyze embedded system fundamentals, processor architectures, and design methodologies.
2. Implement real-time operating system concepts and task management using Free RTOS.
3. Examine embedded Linux architecture, boot process, and device driver concepts.
4. Develop embedded applications using STM32 Microcontrollers and peripheral interfacing through STM32CubeIDE.
5. Apply software testing, debugging, and Edge AI concepts to solve real-world embedded applications.

Course Outcomes:

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

CO1: Explain embedded system fundamentals, processor architecture, design metrics, and development lifecycle models.

CO2: Analyze RTOS concepts including Scheduling, Synchronization, Inter task Communication, and Free RTOS basics.

CO3: Illustrate embedded Linux concepts including boot process, kernel configuration, device drivers, and cross-compilation.

CO4: Develop embedded applications using STM32 Microcontrollers and STM32CubeIDE for peripheral interfacing.

CO5: Apply testing, debugging, and Edge AI techniques for real-world embedded applications.

Course Contents		
Unit I	**Fundamentals of Embedded Systems & Processor Architecture**	**(09 Hours)**
Introduction to Embedded Systems, Classification and Characteristics of Embedded Systems, Design Metrics and Optimization, Processor Architecture, Microcontrollers vs Microprocessors vs SoC, ARM Cortex Architecture Overview, Embedded Hardware-Software Co-design, Embedded Design Lifecycle, Software Development Models: Waterfall Model, Applications of Embedded Systems in Industry.		
Exemplar: Airbag System in a Car/ Smart Washing Machine/ Mars Pathfinder/ Smart Home system		
Mapping of Course Outcomes for Unit I: CO1		
Unit II	**Real-Time Operating Systems**	**(09 Hours)**
Real-time System Concepts, Tasks and Threads, Scheduling Algorithms, Context Switching, Priority Inversion, Deadlock, Mutual Exclusion, Semaphore and Mutex, Intertask Communication, Memory Management in RTOS, Introduction to Free RTOS.		

Exemplars: Smart Traffic Signal Control System based on Free RTOS and Equivalent		
Mapping of Course Outcomes for Unit II: CO2		
Unit III	**Embedded Linux Systems**	**(08 Hours)**
Need for Embedded Linux, Embedded Linux Architecture, Boot Process, Bootloaders, U-Boot, Kernel Configuration, Device Drivers, File Systems, Cross Compilation, Debugging Tools.		
Exemplar: Smart IP Camera (CCTV) based on Embedded Linux, Smart TVs. Routers, Set-top boxes, ATM machines, Automotive infotainment systems and Equivalent		
Mapping of Course Outcomes for Unit III: C03		
Unit IV	**STM 32 Programming and Peripheral Interfacing**	**(09 Hours)**
Introduction to STM32 Microcontrollers, Introduction to STM32CubeIDE, GPIO Programming, Timers, Interrupts, ADC/DAC, UART Communication, SPI Communication, I2C Communication, Sensor Interfacing, Actuator Interfacing, Mini Application Development.		
Exemplar: **STM32-Based Smart Greenhouse Monitoring Systems and equivalent examples**		
Mapping of Course Outcomes for Unit IV: CO4		
Unit V	**Embedded Software Testing, Edge AI and Industry Applications**	**(09 Hours)**
Unit Testing, Integration Testing, Hardware Debugging, JTAG Debugging, Simulators and Emulators, Introduction to Edge AI, Tiny ML Basics, Deployment using Tensor Flow Lite, Deployment using Edge Impulse. **Industry Applications:** Smart Agriculture, EV Charging Systems, Industrial Automation, Smart Healthcare, Automated Vending Systems.		
Exemplar : STM32-Based Tiny ML Smart Agriculture System		
Mapping of Course Outcomes for Unit V: CO5		

Learning Resources

Textbooks:

1. Raj Kamal, Embedded Systems: Architecture, Programming and Design, Tata McGraw Hill , 4th Edition 2020
2. Frank Vahid & Tony Givargis, Embedded System Design: A Unified Hardware/Software Introduction, Wiley Oct 2021.
3. Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C, E-Man Press, Jan 2023.

Reference Books:

1. Richard Barry, Using the Free RTOS Real Time Kernel, Oct 2024
2. Brian Amos, Hands-On RTOS with Microcontrollers: Building Real-Time Embedded Systems using Free RTOS, STM32 MCUs, and SEGGER Debug Tools, Packet,2nd Edition 2023-24
3. Christopher Hallinan, Embedded Linux Primer: A Practical Real-World Approach, Pearson,2nd Edition 2011
4. Jonathan Corbet, Alessandro Rubini, Greg Kroah-Hartman, Linux Device Drivers, O'Reilly,3rd Edition, Publication Year-2005
5. Muhammad Ali Mazidi, Shujen Chen, Eshragh Ghaemi, STM32 Arm Programming for Embedded Systems, Micro DigitalEd., 1st Edition 2019
6. Pete Warden & Daniel Situnayake, TinyML: Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers, O'Reilly, 2020

7. Cem Ünsalan, Berkan Höke, Eren Atmaca, Embedded Machine Learning with Microcontrollers, Oct 2025

MOOC/NPTEL Courses:

1. NPTEL Course on "Embedded System Design with ARM" Link of the Course: https://nptel.ac.in/courses/106/105/106105193/

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024Course)

PCC-352-ETC: Broadband Communication

Teaching Scheme	Credits	Examination Scheme
Theory: 03 Hours/Week	03	**CCE* Marks:** 30 Marks **End Semester (Theory) :**70 Marks

Prerequisite Courses, if any: Cellular Network

Companion Course, if any: Broadband Communication Laboratory

Course Objectives:

To make students understand

1. Fundamentals of broadband communication technologies and Quality of Service (QoS) requirements in modern telecom networks.
2. Fiber Optic Communication Systems, GPON/EPON technologies, FTTH architecture, and WDM concepts used in broadband networks.
3. The evolution, architecture, and advancements of mobile broadband technologies from 3G to 5G.
4. The knowledge of broadband wireless technologies and their applications in present-day communication systems.
5. The practical and industry-oriented skills related to broadband networking, configuration, deployment, and troubleshooting.

Course Outcomes:

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

CO1: Explain various broadband technologies used in the telecom industry and the significance of Quality of Service (QoS) parameters.
CO2: Analyze fibre optic communication technologies, GPON/EPON systems, FTTH architecture, and WDM concepts used in broadband networks.
CO3: Analyze the architecture, features, and technological advancements of mobile broadband technologies from 3G to 5G networks.
CO4: Evaluate broadband wireless technologies and their applications in modern communication networks.
CO5: Analyze industry-oriented networking tools and practices, configuration and broadband deployment.

Course Contents

Unit I	Introduction to Broadband Ecosystem & Industry Overview	(09 Hours)

Evolution from PSTN TO Gigabit Internet, Broadband Market Landscape (ISP, Telecom Operator, Data Centers, Internet Architecture & Service provider, Multiplexing in Broadband TDM ,FDM . Broadband performance metrics (Latency, Throughput, Jitter) QoS & SLA concepts		
Exemplar: A) Draw and explain the end-to-end architecture of Internet service delivery from Data Centres to End Users. **OR** B) Identify the roles of ISPs, Telecom Operators, Internet Exchange Points (IXPs), and Content Delivery Networks (CDNs).		
Mapping of Course Outcomes for Unit I: CO1		
Unit II	**Introduction to Fibre Optic Communication for Broadband Networks**	**(09 Hours)**
Optical communication bands, selection of optical sources and photodetectors, types of optical fibres (brief introduction), GPON and EPON – concepts and architecture, FTTH- concept (ONT, OLT, and BNG) fiber network planning fundamentals.		
Exemplar : FTTH Deployment Case Study- Study a real-world FTTH deployment by BSNL FTTH, JioFiber, Airtel Xstream Fiber, or Tata Play Fiber.		
Mapping of Course Outcomes for Unit II: CO2		
Unit III	**Broadband Access Networks (ISP Technologies)**	**(09 Hours)**
Introduction to DWDM (Architecture, DWDM Principles, advantages, Deployment) Wireless broadband concepts -Wi-Fi (IEEE 802.11), WiMAX (IEEE 802.16),3G, 4G LTE, 5G overview, Satellite broadband communication - Internet System(overview), Spectrum management.		
Exemplar: A) Study a telecom backbone network employing DWDM technology. **OR** B) Case Study: Analyze how DWDM enables high-capacity transmission for long-haul and metro networks.		
Mapping of Course Outcomes for Unit III: CO3		
Unit IV	**Wireless Broadband Communication**	**(09 Hours)**
Introduction to Cloud Computing, Evolution of cloud computing, Cloud service models: IaaS ,PaaS, SaaS. Data centre basics, Challenges in traditional cloud networking. Edge computing basics, Cloud Networking basics. Introduction to SDN, Traditional vs SDN networking, Control plane and data plane, SDN architecture, OpenFlow basics.Virtual networking concepts Traffic engineering in cloud, QoS management, Dynamic bandwidth allocation, Security in SDN-cloud networks, QoS management.		
Exemplar: Create a timeline showing the evolution from traditional computing to virtualization, cloud computing, edge computing, and distributed cloud architectures.		
Mapping of Course Outcomes for Unit IV: CO4		
Unit V	**Broadband Switching and Networking Protocols with Emerging Technologies**	**(09 Hours)**

Ethernet IP, TCP, UDP, ATM, Traditional MPLS, Advanced Routing Protocols OSPF/ BGP/ IS-IS, SDN based MPLS, FRAME RELAY, SONET/SDH Network performance using QoS, Network virtualization Concepts. AI in Network Management, Broadband for IoT, Introduction to 6G Evolution.

Exemplar:

A) Prepare a protocol comparison chart and discuss their role in broadband networks.

OR

B) Analyze how MPLS improves traffic engineering and QoS.

Mapping of Course Outcomes for Unit V: CO5

Learning Resources

Textbooks:

1) Forouzan, B. A., Data Communications and Networking, 5th Edition, McGraw-Hill Education, 2012.
2) Stallings, W., High-Speed Networks and Internets: Performance and Quality of Service, 2nd Edition, Pearson Education/Prentice Hall, 2001.
3) Keiser, G., Optical Fiber Communications, 5th Edition, McGraw-Hill Education, 2013.
4) Black, U., Broadband Networking: ATM, SDH and SONET, 2nd Edition, Prentice Hall, 1999.

Reference Books:

1) Ramaswami, R., Sivarajan, K. N., and Sasaki, G. H., Optical Networks: A Practical Perspective, 3rd Edition, Morgan Kaufmann Publishers, 2009.
2) Rappaport, T. S., Wireless Communications: Principles and Practice, 2nd Edition, Pearson Education, 2002.
3) Tanenbaum, A. S. and Wetherall, D. J., Computer Networks, 5th Edition, Pearson Education, 2011.
4) Agrawal, G. P., Fiber-Optic Communication Systems, 4th Edition, Wiley India, 2010.
5) Nicopolitidis, P., Obaidat, M. S., Papadimitriou, G. I., and Pomportsis, A. S., Modeling and Simulation of Computer Networks and Systems: Methodologies and Applications, 1st Edition, Elsevier, 2015.

MOOC / NPTEL Courses:

1. NPTEL Course "**Computer Networks And Internet Protocol**"
   Link of the Course: https://nptel.ac.in/courses/106105183
2. NPTEL Course "**Wireless Ad Hoc and Sensor Networks**"
   Link of the Course: https://nptel.ac.in/courses/106105160

Savitribai Phule Pune University

Third Year of Electronics and Telecommunication Engineering (2024Course)

PCC-353-ETC: Embedded System Design Lab

Teaching Scheme	Credits	Examination Scheme
Practical:02Hours/Week	01	**TermWork**:25Marks **Practical**: 25Marks

Companion Course, if any: Embedded System Design (PCC-352-ETC)

Course Objective: To make students understand

- Real-time embedded systems GPIO operations, timing mechanisms and hardware interfacing using STM32 microcontrollers and modern IDE tools.
- Complex and communication-driven embedded and Real-Time Operating Systems (RTOS)
- Integration of Intelligent Algorithms with hardware constraints to solve complex, real-world societal and industrial challenges.

Course Outcome:

Students will be able to:

CO1: Design and implement automated, hardware-interfaced embedded systems by configuring STM32 GPIOs, hardware timers for delays and integrating DC motor control circuits.

C02: Develop and evaluate scalable, deterministic embedded solutions.

C03: Develop and evaluate an intelligent, data-driven Edge AI application Smart Embedded Application.

List of Experiments

Group A: Any Three Experiments to be Performed

1. LED blinking on STM 32 microcontroller using GPIO output pins
2. Interface push button and LED using GPIO input pins
3. Timer Programming on STM32 Microcontrollers
4. DC Motor Interacting with STM 32 Microcontroller

Group B: Any Five Experiments to be Performed

5. ADC and Sensor Interfacing
   a) Interface temperature/LDR sensor with STM32
   b) Read analog values using ADC
6. Transmit and receive data between STM32 and PC/another device
7. SPI/I2C Communication (Interface EEPROM/LCD/sensor module using SPI or I2C protocol)
8. Task Scheduling using Free RTOS
9. Inter task Communication in Free RTOS (Implement semaphore/mutex/queue communication)
10. Embedded Linux Experiment
    a) Kernel configuration and boot process study using U-Boot
    b) Basic Linux command execution / cross-compilation demo

Group C : Any one Mini project/Case study in a Group of 3-4 Students

11. Case Study/Mini project: Edge AI / Smart Embedded Application

Build an application such as: Smart agriculture monitoring/ Smart vending machine not limited to this can be considered

12: Case Study/Mini project: Edge AI / Smart Embedded Application Home automation system/ Smart healthcare monitoring n o t limited to this can be considered.
Virtual LAB Links: 1. https://vlabs.iitkgp.ac.in/rtes/ 2. https://esd-coep.vlabs.ac.in/List%20of%20experiments.html 3. https://esd-iitr.vlabs.ac.in/

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement
3	Ckt/Logic Design of given problem statement
4	Diagram with theory for operation
5	Experimentation
6	Observation/ Result table
7	Graphs if any
8	Conclusions
9	Mention real life examples concerned with the respective experiments
Guide lines for Laboratory/Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

PCC-354-ETC: Broadband Communication Laboratory

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**Term Work:** 25 Marks **Oral:** 25 Marks

Companion Course, if any: Fiber-Optic Communication, Computer network

Course Objectives:

The students will able to Understand

1. Model, configure, and secure scalable broadband communication infrastructures and internet service provider (ISP) networks
2. Software-defined broadband networks by analyzing wireless architectures, implementing traffic-specific Quality of Service (QoS) engineering, Fiber-To-The-Home (FTTH) telecom infrastructures using advanced simulation and monitoring tools.
3. Collaborative engineering skills in students by enabling them to design and simulate, cellular networks (3G/4G/5G), IoT ecosystems, or software-defined architectures (SDN).

Course Outcome: The students will able to

CO1: Configure and analyze broadband communication networks using routing, switching, wireless technologies, IP services, QoS mechanisms, security techniques, and traffic analysis tools.

CO2: Analyze and design optical, cellular, and IoT-enabled broadband networks using GPON/EPON, WDM, FTTH, and next-generation wireless communication technologies.

CO3: Apply Software Defined Networking concepts for centralized network control and resource Management.

List of Experiments

Group A: Fundamental Experiments (Any 4) [Use any Software]

1)Study of broadband communication architecture and ISP network. (LAN, MAN, WAN, ISP backbone mdeling) using MATLAB / CISCO PACKET TRACER/Equivalent

2) Design ISP Broadband Network using Cisco Packet Tracer

3) IP addressing and Network Services like IPv4, IPv6, VLSM and DHCP Configuration

OR

DHCP, DNS and Subscriber Management Services (using MATLAB / CISCO PACKET TRACER/Equivalent)

4) Develop static routing and OSPF routing Configuration

OR

Develop VLAN and Inter-VLAN Routing (using MATLAB / CISCO PACKET TRACER//Equivalent)

5) Secure Broadband Network using ACLs and Firewall Rules.

OR

NAT/PAT Implementation and Internet Connectivity (using MATLAB / CISCO PACKET TRACER//Equivalent)

6) Analysis and Demonstration of WDM-Based Optical Communication System using MATLAB /Equivalent

Group B: Intermediate Level Broadband Experiments (Any 3) [Use any Software]

1.Wireless Broadband Network Setup **OR** Deployment of Wi-Fi to WiMAX (Using MATLAB/Equivalent)
2. QoS Configuration for VoIP and IPTV Traffic (using Wireshark/ MATLAB//Equivalent) **OR** Traffic Monitoring and Packet Analysis using Wireshark
3. Study of GPON/EPON architecture and FTTH network components using MATLAB//Equivalent
4. SDN-Based Broadband ISP Network Management
Group C: Skill-Based (Any 1) [Use any Software] (To be performed in Group of 3-4 students)
1.Case study -Simulation and Performance Evaluation of 3G, 4G LTE, and 5G Networks in terms of speed, latency, bandwidth efficiency, and user capacity.
2.Case study - IoT Smart Home over Broadband Network
3.Case Study- Introduction to SDN Architecture and Centralized Network Control using MATLAB
4.Mini Project: Design of ISP network for college campus / FTTH deployment planning/Wireless broadband optimization / QoS analysis of multimedia traffic
Virtual LAB Links: **a.** https://www.netacad.com/cisco-packet-tracer **b.** https://in.mathworks.com/products/communications.html **c.** https://www.nsnam.org/

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

PEC-361 (A) -ETC: Elective II (Web Technology)

Teaching Scheme	Credits	Examination Scheme
Theory: 03 Hours/Week	03	**CCE* Marks**: 30 Marks **End Semester (Theory):** 70 Marks

Prerequisite Courses: Object-Orientated Programming, Advanced JAVA Programming

Companion Course: PEC-363-section I Lab (Web Technology Laboratory)

Course Objectives:

To make students understand

1. The fundamental concepts of HTML and CSS used in creating basic web pages
2. Design interactive web pages using JavaScript, DOM manipulation, event handling, and modern ES6 features
3. The concepts of jQuery and PHP for developing interactive and dynamic web pages
4. The principles of component-based architecture and implement dynamic user interfaces using React.js
5. The fundamentals of web security, secure web communication, cyber threats, and Search Engine Optimization (SEO) techniques for improving website security, visibility, and performance.

Course Outcomes:

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

CO1: Recall and design basic web pages using HTML and CSS used in standard web page development.

CO2: Develop interactive webpages using basic JavaScript concept, DOM manipulation, event handling and ES6 feature

CO3: Develop interactive and dynamic web pages using jQuery and PHP with form handling, event handling, and database connectivity concepts.

CO4: Develop basic single-page web applications using React js components and state management.

CO5: Apply basic web security practices and SEO techniques to analyze and improve website security and visibility.

Course Contents

Unit I	Introduction to HTML and CSS	(08 Hours)

Web Fundamentals: Architecture of WWW, HTTP/HTTPS protocols, servers, client–server model, URL structure, and the role of Web Browsers vs. Web Servers.

HTML: Structure of HTML Document, HTML Tags and Elements, Text Formatting, Lists, Links, Images, Tables, Forms and Input Controls.

CSS: Introduction to CSS, CSS Syntax and Selectors, Styling Text, Colors, Backgrounds, Margins, Padding, Inline, Internal and External CSS, Basic Webpage Layout using CSS. Introduction to BOOTSRAP and its components.

Exemplar: Create the structural skeleton for an "Electronic Component Data Sheet" and enhance the readability by designing using CSS.

Task 1: Use a text editor to write an HTML document that includes a <header> for the component name, a <table> for pin configurations, and a <form> for a "Request Quote" section.

Task 2: Create an external CSS file. Implement the Box Model to create distinct margins and

padding between the table and the form. Use a two-column layout to place the image of the component next to its description.		
Mapping of Course Outcomes for Unit I: CO1		
Unit II	**Client-side Technology: JavaScript and DOM**	**(10 Hours)**
Introduction to JavaScript: Features and importance of JavaScript, Client-side vs Server-side scripting, JavaScript syntax and structure, Embedding JavaScript in HTML. Variables, Data Types and Operators, Control Statements and Functions, Arrays and Strings. **DOM Manipulation and Event Handling**: Accessing HTML elements, Event handling basics (on click, on change, on mouse over), Basic Form Validation. **Introduction to ES6 Features**: let and const, Arrow Functions, Template Literals, Default Parameters.		
Exemplar: Enhance a blogging application using JavaScript by implementing an "Add Entry" feature to dynamically add and display blog posts using DOM manipulation and event handling.		
Mapping of Course Outcomes for Unit II: CO2		
Unit III	**Web Scripting using jQuery and PHP**	**(10 Hours)**
JQuery: Introduction to jQuery, Loading jQuery, selecting elements, changing styles, creating, appending and removing elements, handling events, jQuery Effects, Form Handling using jQuery, Basic Validation using jQuery. **PHP:** Introduction to PHP, Features, Demo code, PHP SCRIPTS, PHP conditional statements and Loops, Functions, String manipulation, Arrays & Functions, pattern matching, Form handling, Cookies and Sessions tracking, File Handling, Exception Handling, E-mail validations, MySQL with PHP.		
Exemplar : Design an Interactive Calculator Webpage using jQuery Develop a Student Registration Web Application using PHP and MySQL		
Mapping of Course Outcomes for Unit III: CO3		
Unit IV	**Introduction to React.js**	**(10 Hours)**
Introduction to Front-End Frameworks and React.js, Features and Advantages of React.js, Setting up React Environment using Node.js and npm, Introduction to JSX Syntax, Components in React, Props and State Management, Event Handling, Lists, Keys & Forms, Component Lifecycle, Introduction to React Hooks (use State, use Effect), React router, Styling in react.		
Exemplar: Basic Single Page Application (SPA). Implement a React component named Counter that displays a numeric value starting at 0. Use the use State hook to manage the count. Execute an event handler that increments the count when a button is clicked. Additionally, apply conditional rendering to display the text 'High Alert!' in red only when the count exceeds 10.		
Mapping of Course Outcomes for Unit IV: CO4		
Unit V	**Web Security and Search Engine Optimization (SEO)**	**(07 Hours)**
Introduction to Web Security: Basics of Web Security, Need of Web Security, Cyber Threats, Malware, Phishing, Website Vulnerabilities, Web Attacks, Secure Browsing Practices. **Web Security Mechanisms:** HTTPS, SSL/TLS, Authentication & Authorization, Password Security, Firewalls, Cookies & Sessions, Basic Secure Coding Concepts. **Introduction to SEO:** Introduction to Search Engine Optimization, Working of Search Engines, Web Crawlers & Indexing, Importance of SEO, Types of SEO (On-page, Off-page, Technical SEO). **SEO Tools & Optimization Techniques:** Keyword Research, Meta Tags, Backlinks, Page Ranking, Mobile Friendly Websites, Google Search Console, SEO Analysis Tools, Social Media Optimization.		
Exemplar:		

1. Comparison of SEO optimization techniques used by educational, commercial, and social media websites. Students may choose websites with teacher approval. Tools Required: Google Chrome Browser, Internet Connection Online SEO Tools: SEO Site Checkup, GT metrix, Google Page Speed Insights.
2. Case studies on cyber-attacks.

Mapping of Course Outcomes for Unit V: CO5

Learning Resources

Textbooks:

1. Jeffrey C.Jackson, "Web Technologies: A Computer Science Perspective", 2nd Edition, Pearson Education, 2007, ISBN 978-0131856035.
2. E. Enge, S. Spencer, and J. Stricchiola, "The Art of SEO", 3rd Edition. Sebastopol, CA, USA: O'Reilly Media, 2015. ISBN: 9781491948965.
3. Steven Holzner, "PHP: The Complete Reference", McGraw Hill Professional, 2008

Reference Books:

1. David Flanagan," JavaScript: The Definitive Guide", 7th Edition, O'Reilly Media, 2020.
2. W. Stallings, Network Security Essentials: Applications and Standards, 6th Edition,Noida, India: Pearson Education, 2019.

e-Books:

1. https://goalkicker.com/ReactJSBook/
2. https://ibcomputerscience.xyz/wp-content/uploads/2017/09/1469306509-aab008e7ca1d715326928dade3196b2d-Web-Technologies-A-Computer-Science-Perspective-J.-Jackson-Pearson-2007-BBS.pdf
3. https://eloquentjavascript.net/

MOOC / NPTEL/YouTube Links:

1. https://onlinecourses.swayam2.ac.in/e-learning/preview/aic22_ge30
2. https://www.coursera.org/specializations/seo
3. https://www.youtube.com/@GoogleSearchCentral
4. https://www.youtube.com/@Codevolution
5. https://www.coursera.org/specializations/web-design

e-Resources:

1. https://owasp.org/www-project-web-security-testing-guide
2. https://getbootstrap.com/docs/5.0/getting-started/introduction/
3. https://github.com/the-road-to-learn-react

Free Extra Certification:

1. https://onlinecourses.swayam2.ac.in/e-learning/preview/aic20_sp11
2. https://www.freecodecamp.org/learn/javascript-algorithms-and-data-structures/
3. https://www.coursera.org/specializations/front-end-development-using-react-specialization
4. https://www.freecodecamp.org/learn/front-end-development-libraries/
5. https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr25_ed123
6. https://www.coursera.org/professional-certificates/google-digital-marketing-ecommerce
7. https://academy.hubspot.com/courses/seo-training-course

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024 Course)		
PEC-361 (B) -ETC: Elective – II (Digital Image Processing)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE* Marks**: 30 Marks **End Semester (Theory):** 70 Marks
Prerequisite Courses, if any: Signals and Systems, Digital Signal Processing		
Companion Course, if any: PEC-363-section I Lab (**Digital Image Processing Laboratory)**		

Course Objectives:

To make students understand

1. The fundamentals of digital image processing, image representation, and color models.
2. Image enhancement techniques in spatial and frequency domains.
3. Image segmentation and feature extraction methods.
4. Image compression techniques for efficient storage and transmission.
5. AI-driven computer vision systems and emerging real-world applications.

Course Outcomes:

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

CO1: **Explain** the fundamentals of digital image processing, image representation, and color models for image analysis.

CO2: **Apply** spatial domain enhancement and filtering techniques for image quality improvement and noise reduction.

CO3: **Implement** frequency domain enhancement and image segmentation techniques for image analysis and feature extraction

CO4: **Analyze** image compression techniques using DCT and DWT for evaluating compression performance**.**

CO5: **Apply** computer vision and AI techniques to study intelligent image and video processing solutions for real-world applications.

Course Contents		
Unit I	**Fundamentals of Digital Image Processing**	**(09 Hours)**
Fundamental steps in image processing, components of Image Processing, Image formation in the eye, Image Sampling and Quantization, types of images, Image Histogram, image file formats, basic relationships between pixel, mathematical operations performed on images, set operations, color fundamentals, Color Models – RGB, CMY, HSI, chromaticity diagram		
Exemplar: Smart Traffic Monitoring System using CCTV Image Acquisition Study how digital cameras acquire traffic images and how preprocessing improves vehicle detection accuracy.		
Mapping of Course Outcomes for Unit I:CO1		
Unit II	**Image Enhancement in Spatial Domain**	**(09 Hours)**

Introduction to Image Enhancement, Need for Image Enhancement, Image enhancement fundamentals Spatial Domain Fundamentals, Concept of spatial domain processing, Point processing operations, Neighborhood processing operations, Relationship between pixels and masks .Gray-Level Transformations, Image negative, Log transformation, Power-law (Gamma) transformation, Piecewise linear transformation, Contrast stretching, Gray-level slicing, Bit-plane slicing. Spatial Filtering Techniques, Smoothing Filters: Mean filter, Weighted average filter, Median filter Sharpening Filters, Gradient operators, Laplacian filtering, High-boost filteringNoise Models and Noise Reduction, Gaussian noise, Salt and pepper noise, Periodic noise, Noise removal using spatial filters.

Exemplar

Medical X-ray Image Enhancement Analyze how enhancement techniques improve visibility of fractures and abnormalities in medical images

Mapping of Course Outcomes for Unit II:C02

Unit III	Image Enhancement and Segmentation in Frequency Domain	(09 Hours)

Introduction to Frequency Domain Processing, Fundamentals of frequency domain image processing Spatial domain vs frequency domain processing, Concept of spatial frequency: Low-frequency components, High-frequency components. Frequency Domain Image Enhancement, Low-Pass Filtering (Image Smoothing), Ideal Low Pass Filter (ILPF), Butterworth Low Pass Filter (BLPF), Gaussian Low Pass Filter (GLPF). High-Pass Filtering (Image Sharpening), Ideal High Pass Filter (IHPF), Butterworth High Pass Filter (BHPF), Gaussian High Pass Filter (GHPF), Image Segmentation Techniques, Edge-Based Segmentation, Detection of discontinuities: Roberts operator, Prewitt operator, Sobel operator, Canny edge detector, Threshold-Based Segmentation: Global thresholding, Adaptive thresholding, Region-Based Segmentation, Region growing, Region splitting and merging.

Exemplar

Defect Detection in Manufacturing Industry .Study segmentation methods used for identifying cracks and defects in electronic components or mechanical parts.

Mapping of Course Outcomes for Unit III:C03

Unit IV	Image Compression	(08Hours)

Need of Image Compression, Image compression model, Types of image compression- Lossy and lossless, Huffman coding for image compression, Compression using Discrete Cosine Transform, 8X8 block DCT, processing pipeline, Wavelet based compression- DWT, Compression ratio, relative data redundancy, compression ratio vs quality trade-off.

Exemplar

Use of DCT in JPEG Image compression

Mapping of Course Outcomes for Unit IV: C04

Unit V	AI-Driven Computer Vision Systems and Applications	(09 Hours)

Introduction to computer vision, AI-assisted image processing, Basics of machine learning for images Object detection concepts, Face recognition fundamentals, Real-time video processing, Embedded vision systems, Edge AI and IoT vision devices, Ethical issues in AI-based vision systems, Emerging applications: Autonomous vehicles, Smart cities, Healthcare diagnostics, Agriculture monitoring

Exemplar:

Face Recognition System for Smart Attendance. Analyze the working of AI-based face recognition systems used in modern educational institutions and industries

Mapping of Course Outcomes for Unit V:CO5

Learning Resources

Textbooks:

1. Gonzalez & Woods, "Digital Image Processing", Pearson Education, 4th Edition, 2018.
2. Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins, Digital Image Processing Using MATLAB, 3rd Edition,2020.
3. Computer Vision: Algorithms and Applications — Richard Szelisk, Publication Springer,2022

Reference Books:

1. Jain Anil K., "Fundamentals Digital Image Processing", Prentice Hall India, 4th Edition. Reprint 2015
2. Khalid Sayood, "Introduction to Data Compression", 5th Edition, Morgan Kaufmann,Elseveir 2026
3. Deep Learning for Vision Systems — Mohamed Elgendy,1st Edition,Manning Publications ,2020
4. Learning OpenCV 4 Computer Vision with Python 3 — Joseph Howse & Joe Minichino,3rd Edition 2020

MOOC / NPTEL Courses:

Digital Image Processing (IIT kharagpur) : https://nptel.ac.in/courses/117105135
Digital Image Processing. https://nptel.ac.in/courses/117/105/117105079
Digital Image Processing." https://nptel.ac.in/courses/106/105/106105032

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

PEC-361 (C) -ETC: Elective II (Network and Cyber Security)

Teaching Scheme	Credits	Examination Scheme
Theory: 03 Hours/Week	03	**CCE* Marks:** 30 Marks **End Semester (Theory):**70 Marks

Prerequisite Courses, if any: Nil

Companion Course, if any: PEC-363-section I Lab (Network and Cyber Security Lab)

Course Objectives:

To make students understand

1. Fundamentals of computer security, security principles, security attacks, and basic Cryptography techniques
2. Advanced approaches of encryption, decryption and authentication algorithms
3. Internet security protocols, authentication techniques and countermeasures
4. Cyber threats, malware, system vulnerabilities, and web security issues
5. Cyber laws, data privacy regulations and governance frameworks

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

CO1: Apply basic cryptographic techniques for enhancing security.

CO2: Explain advanced cryptographic techniques and Authentication algorithms.

CO3: Interpret internet security protocols and authentication mechanisms and counter measures.

CO4: Illustrate cyber security threats, malware behavior, system vulnerabilities, and web security issues.

CO5: Analyze cyber laws, data privacy regulations, and cyber governance frameworks.

Course Contents

Unit I	Fundamentals of Network security and Cryptography	(09 Hours)

Need for security, Principles of security, Types of Security attacks, Security services, Security Mechanisms, A model for Network Security, Substitution techniques (Caesar cipher, Vernam cipher , Playfair cipher), Transposition techniques (Rail fence and Columnar transposition), Symmetric and Asymmetric key cryptography, Steganography.

Exemplar : Online banking applications protect customer accounts using passwords, OTPs, and encryption to prevent unauthorized access and financial fraud.

Mapping of Course Outcomes for Unit I:C01

Unit II	Symmetric, Asymmetric Cryptography and Authentication	(09 Hours)

Block Cipher, Stream Cipher, Modes of operation in Block Cipher, Symmetric Key Algorithms (DES, AES), Asymmetric Key Algorithms (RSA, Diffie-Hellman Key Exchange), Authentication algorithms, SHA, MAC, Passwords, Authentication Tokens, Certificate-based Authentication, Biometric Authentication, Kerberos, Key Distribution Center (KDC).

Exemplar: Secure Authentication and Encrypted Communication System

Mapping of Course Outcomes for Unit II:CO2

Unit III	Internet Security Protocols	(09 Hours)

Secure Socket Layer (SSL), Transport Layer Security (TLS), Secure Hyper Text Transfer Protocol (SHTTP), Time Stamping Protocol (TSP), Electronic Money, Email Security, Security in 5G, Virtual Private Network (VPN), IoT Security, IPsec, Countermeasures: Firewall, Secure Inter-branch Payment Transactions, Virtual E-Lections.

Exemplar: Network Security Analysis using Wireshark

Mapping of Course Outcomes for Unit III: CO3

Unit IV	Foundations of Cyber Security	(09 Hours)

Definition and Importance of Cyber Security, Cyber Security Goals, Cyberspace and its Components, Challenges in Cyberspace: Threats, Vulnerabilities and Risks. Evolution of Cybersecurity, Cyber Attacks and Malware, Intrusion Detection and Prevention Systems, Securing Your Digital Presence: Password Security and Management, Multi-Factor Authentication (MFA), Social Engineering & Online Scams, Secure Browsing and Phishing Awareness, Ransomware. Common Web Vulnerabilities: SQL Injection, Cross Site Scripting (XSS), Cross Site Request Forgery (CSRF).

Exemplar: Wanna Cry ransomware, phishing and social engineering incidents, MFA bypass scenarios, AI-enabled deep fake attacks, IDS/IPS deployment examples (Snort/Suricata), and email authentication mechanisms.

Mapping of Course Outcomes for Unit IV: CO4

Unit V	Cyber Ethics and Cyber Governance	(09 Hours)

Cyber Laws, Cyber Crimes: Definition, Classification and The Vicious Cycle of Cybercrime.
Cyber Ethics and Professional Responsibility: Ethical Hacking Concepts, Responsible Use of Social Media, Professional Ethics for Engineers.
Data Privacy and Cyber Governance: Personal Data Protection Concepts, Data Breach and Privacy Risks, Cyber Security Policies and Governance, National Cyber Security Policy (India), International Cyber Security Standards, Introduction to: ISO/IEC 27001, GDPR (General Data Protection Regulation), Careers in Cyber Security.

Exemplar: Misuse of organizational computer resources violating professional ethics and cyber policies.

Mapping of Course Outcomes for Unit V:CO5

Learning Resources

Textbooks:

1. William Stallings, "Cryptography and Network Security: Principles and Practice", Pearson Education, 4th Edition, 2006.
2. Atul Kahate, "Cryptography and Network Security", McGraw Hill, 3rd Edition, 2013.
3. Nilakshi Jain and Ramesh Menon, "Cyber Security and Cyber Laws", Wiley India, 1st Edition, 2020.
4. William Stallings and Lawrie Brown, "Computer Security: Principles and Practice", Pearson Education, 4th Edition, 2017.

Reference Books:

1. Behrouz A. Forouzan and Debdeep Mukhopadhyay, "Cryptography and Network Security", McGraw Hill, 2nd Edition, 2012.
2. Mark Stamp, "Information Security: Principles and Practice", Wiley India, 2nd Edition, 2011.
3. W.M. Arthur Conklin and Greg White, "Principles of Computer Security", TMH, 4th Edition, 2015.
4. Neal Krawetz, "Introduction to Network Security", CENGAGE Learning Distributor, 1st Edition,

2007.
5. Bernard Menezes, "Network Security and Cryptography", CENGAGE Learning Distributor, 1st Edition, 2010.
6. Michael E. Whitman and Herbert J. Mattord, "Principles of Information Security", Cengage Learning, 6th Edition, 2017.
7. Surya Prakash Tripathi, Ritendra Goel and Praveen Kumar Shukla, "Information Security, Cyber Laws and Cyber Forensics", Wiley India, 1st Edition, 2014

MOOC / NPTEL Courses:

1. NPTEL Course on: Introduction to Cyber Security, Prof. Indranil Sengupta, IIT Kharagpur.
Link:https://onlinecourses.swayam2.ac.in/nou19_cs08/preview
2. NPTEL Course on: Cyber Security and Privacy, Prof. Saji K. Mathew, IIT Madras.
Link:https://nptel.ac.in/courses/106106248
3. NPTEL Course on: Ethical Hacking, Prof. Indranil Sengupta, IIT Kharagpur.
Link:https://nptel.ac.in/courses/106105217
4. NPTEL Course on: Internet Crimes and Cyber Security, Prof. K.V.K. Santhy and Prof. B. Md. Irfan, NALSAR University of Law.
Link:https://nptel.ac.in/courses/129106894

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering(2024Course)

PEC-361 (D) -ETC: Elective II (CMOS Process Technology)

Teaching Scheme	Credits	Examination Scheme
Theory:03Hours/Week	03	**CCE*Marks**:30Marks **End Semester (Theory):**70Marks

Prerequisite Courses, if any: Basic Electronics, Electronics Circuits

Companion Course, if any: PEC-363-section I (CMOS Process Technology Lab)

Course Objectives:

To make students understand

1. Operation of MOSFETs and CMOS technology fundamentals
2. CMOS circuit design, layout, and verification using design rules
3. Processes in semiconductor fabrication (oxidation, lithography, etching, doping, deposition)
4. Complete CMOS process integration flow and yield considerations
5. Advanced CMOS technologies (Fin FET, SOI, 3D ICs) and industry applications

Course Outcomes:

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

CO1: Explain MOS transistor operation and CMOS inverter characteristics including VTC, noise margin and power dissipation.

CO2: Design CMOS logic circuits and layouts using CMOS design rules.

CO3: Elaborate oxidation, lithography, doping and deposition processes with respect to process parameters and CMOS device fabrication.

CO4: Explain CMOS latch-up, process integration, and yield-related issues in VLSI fabrication.

CO5: Explain advanced CMOS technologies with respect to scaling challenges, device performance and emerging semiconductor applications.

Course Contents

Unit I	Introduction to MOS Technology and CMOS Fundamentals	(09 Hours)

IC evolution: SSI, MSI, LSI, VLSI and Moore's Law, MOS structure, NMOS and PMOS transistor operation, Long Channel I-V Characteristics, MOS Capacitance Model, Non- Ideal I-V Effects: mobility degradation, velocity saturation, channel length modulation, body effect, CMOS technology and advantages, CMOS inverter: Pull up/Pull down, Operation and VTC, Noise margins, delay, Power dissipation: Static and Dynamic, SPICE modeling of MOSFET, DC, & transient analysis.

Exemplar: Apple A17 Pro (3nm inverter with ±0.3V threshold), Intel Core i7 (power dissipation calculation), Smartphone processors (VTC characteristics), NAND flash memory (MOS capacitor basics), Laptop CPUs)

Mapping of Course Outcomes for Unit I:CO1

Unit II	CMOS Logic and Layout Design	(09 Hours)

CMOS NAND and NOR gates, Transmission gate basics, Design of Combinational circuits using CMOS and TG, Calculation of W/L ratio, Stick diagrams and lambda-based design rules, CMOS layout layers and mask concepts, Layout design of inverter, NAND and NOR gates, Introduction to DRC and LVS

Exemplar: Samsung SRAM cells (NAND/NOR gates), Intel microprocessor data path (transmission gates), FPGA lookup tables (logic design), Qualcomm Snapdragon (W/L ratio optimization), ARM Cortex cores (stick diagrams with lambda rules)

Mapping of Course Outcomes for Unit II: CO2

Unit III	CMOS Fabrication Process – I (Wafer Preparation & Early Processes)	(09 Hours)
Wafer Manufacture: MGS, EGS, Silicon crystal growth: CZ and FZ methods, Wafer formation, Thermal oxidation: Dry and wet oxidation, Doping Processes, Epitaxy: VPE and MBE basics, Photolithography: Positive and negative photoresists, Masking, exposure and development, Optical lithography basics, Cleanroom concepts, contamination control and wafer inspection techniques.		
Exemplar: T S M C wafer fab (silicon crystal growth, RCA cleaning), Intel cleanroom (thermal oxidation), Samsung foundry (photolithography masks), VLSI fab epitaxy (VPE/MBE basics), Semiconductor fab contamination control (yield improvement).		
Mapping of Course Outcomes for Unit III: CO3		
Unit IV	**CMOS Fabrication Process – II (Doping, Etching, Deposition, Metallization)**	**(09 Hours)**
Diffusion and ion implantation, Wet and dry etching, RIE, Thin film deposition: PVD and CVD techniques, Polysilicon and dielectric deposition, Metallization and CMP, Isolation techniques: LOCOS and STI, Basic N-well CMOS fabrication flow, CMOS latch-up and prevention, CMOS process integration and yield issues.		
Exemplar: Intel 14nm Fin FET (ion implantation, RTA dopant activation), TSMC 5nm (RIE etching trenches), Samsung 3D NAND (CVD deposition layers), SK Hynix HBM memory (CMP planarization), Apple A15 (STI isolation, metallization, latch-up prevention)		
Mapping of Course Outcomes for Unit IV:CO4		
Unit V	**Advanced CMOS Technologies and Applications**	**(09 Hours)**
MOSFET Scaling, Short-Channel Effects: Oxide breakdown, DIBL, GIDL, Gate tunnel Current, NBTI, High-k dielectric and metal gate technology, Advanced CMOS devices: FinFET, SOI and GAA, , 3D ICs, TSV and advanced packaging basics, Semiconductor characterization techniques: SEM, TEM and SIMS basics, Emerging applications and future trends in nanoscale CMOS technology		
Exemplar: Suggested Activity: NVIDIA H100 GPU (5nm FinFET), Apple A17 Pro (3nm GAA), IBM PowerPC (SOI technology), SK Hynix HBM3 (3D IC, TSV), Tesla autopilot chip (DIBL, short-channel effects, AI/automotive applications)		
Mapping of Course Outcomes for UnitV:CO5		

Learning Resources

Textbooks:

1. CMOS VLSI Design: A Circuits and Systems Perspective — Neil H. E. Weste and David Money Harris 4th Edition 2011, Addison-Wesley Publisher.
2. CMOS: Circuit Design, Layout, and Simulation — R. Jacob Baker3rd ed. Hoboken, NJ, USA: Wiley-IEEE Press, 2010.

Reference Books:

1. Silicon VLSI Technology: Fundamentals, Practice, and Modeling — James D. Plummer, Michael D. Deal, and Peter B. Griffin, 9th Edition, Prentice Hall, 2000
2. Semiconductor Devices: Physics & Technology— S. M. Sze, M. K. Lee, 3rd edition, John Wiley &Sons, 2012.

MOOC/NPTELCourses:

1. NPTEL Course "VLSI Technology" https://nptel.ac.in/courses/117106093.
2. NPTEL Course on "Digital Circuits" https://nptel.ac.in/courses/117101058

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering(2024Course)		
PEC-362 (A) -ETC: Elective III (Power Electronics)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory:03Hours/Week	03	**CCE*Marks**:30Marks **End Semester (Theory):**70Marks

Prerequisite Courses, if any:
1. Basic Electrical Engineering
2. Basic Electronics Engineering
3. Electronic Circuits

Companion Course (if any): PEC-363-section 2 Lab (Power Electronics Lab)

Course Objectives:
1. Understand the construction, operating principles, characteristics, ratings, and protection techniques of various power semiconductor devices such as SCR, MOSFET, IGBT, GTO, and TRIAC.
2. Analyze the operation and performance of AC–DC power converters under different load conditions using suitable commutation and control techniques.
3. To learn the principles, switching modes, and pulse-width modulation (PWM) control topologies used in DC-to-AC inverters for output voltage regulation and harmonic reduction.
4. To study the design, operation, and control strategies of DC-to-DC choppers and switched-mode power supply (SMPS) regulators.
5. Understand and analyze modern industrial and renewable energy applications of power electronics including UPS systems, battery chargers, electric vehicles, EV charging systems, and solar PV systems.

Course Outcomes:

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

CO1: Analyze the operating characteristics, switching behaviour, ratings, and protection methods of power semiconductor devices for selection in suitable power electronic applications.
CO2: Evaluate the performance of AC–DC power converters under various loading conditions using appropriate commutation and control techniques.
CO3: Analyze and design DC–AC and DC–DC converters using PWM and switching control techniques for efficient power conversion.
CO4: Apply power electronic converter topologies and control strategies for voltage regulation, harmonic reduction, and speed control applications.
CO5: Evaluate and analyze the performance of power electronic systems used in industrial, Renewable energy, UPS, battery charging, and electric vehicle applications.

Course Contents		
Unit I	**Study of Power Devices**	**(12 Hours)**
Construction, V-I characteristics, switching characteristics of SCR, Gate characteristics of SCR, Turn on and Turn Off Mechanism of SCR , Gate Triggering Circuits, various repetitive and non-repetitive ratings of SCR, Over voltage, over current, di/dt and dv/dt protection circuits and their design, Power MOSFET, IGBT, GTO, Triac, UJT Construction working and their characteristics , Introduction to SiC MOSFET (Silicon Carbide MOSFET) and GaN FET (Gallium Nitride Field Effect Transistor).		
Exemplar: SCR Ringing Circuit / UJT Relaxation Oscillator, Snubber Circuit, IGBT & MOSFET Driver Circuit		

Mapping of Course Outcomes for Unit I:CO1		
Unit II	**AC to DC Power Converters**	**(06 Hours)**
Concept of line and forced commutation, Single phase Semi and Full converters using SCR for R and R-L loads and its performance analysis with numerical , Effect of source and load inductance, three phase half controlled Fully controlled bridge converter for R load and its performance analysis.		
Exemplar: Metro and Railway DC drive systems, IC Based Phase Angle Control Rectifier, Simulation of Single-Phase Full-Controlled Bridge Converter		
Mapping of Course Outcome of Unit II: CO2		
Unit III	**DC to AC Converters- Inverters**	**(12 Hours)**
Single phase half and full bridge square wave inverter for R and R-L load using MOSFET / IGBT and its performance analysis and numerical, Cross conduction in inverter, need of voltage control and classifications of voltage control techniques, control of voltage using SPWM (Sinusoidal PWM) and SVPWM (Space Vector PWM, concept and need of harmonic elimination / reduction in inverters, Performance Parameters of Inverter, Three Phase voltage source inverter for balanced star R load with 180 -degree mode of operation.		
Exemplar: Square-Wave Inverter, Sinusoidal PWM (SPWM) Generator, Variable Frequency Drive (VFD) for AC Induction Motor		
Mapping of Course Outcomes: CO3		
Unit IV	**DC to DC Converters-Choppers**	**(06Hours)**
Classification of choppers, Step down chopper and step up chopper for R and RL load and its performance analysis, various control strategies for choppers, types of choppers (isolated and non-isolated) such as type A, B, C, D and E, switch mode power supply (SMPS) such as buck, boost and buck-boost converter.		
Exemplar Switched-Mode Power Supply (SMPS) for Medical or Industrial Instruments		
Mapping of Course Outcome Unit IV:CO4		
Unit V	**Power Electronics Applications**	**(09Hours)**
AC Voltage Controller, Smart LED Driver Systems, battery Charger, Industrial temperature control, DC motor drive, , On-line and Off- line UPS. Electric vehicles- Architecture of EVs, Electric Traction System, BLDC motor control, Battery Management System (BMS) EV Charging Systems, Charging Standards case study of power electronics in electric vehicle and Solar power systems.		
Exemplar Solar PV Maximum Power Point Tracking (MPPT) System, Smart Phone Fast-Charger / Power Bank Module, Residential Uninterruptible Power Supply (UPS) System		
Mapping of Course Outcome:CO5		

Learning Resources

Textbooks:

1. M.H.Rashid, "Power Electronics Circuits Devices and Applications", PHI, 4th Edition, 2017 New Delhi.
2. James Larminie, John Lowry, "Electric Vehicle Technology Explained" John Wiley & Sons Ltd. 2003.
3. M.D.Singh and K.B.Khanchandani, "Power Electronics",TMH, 2nd Edition2006.

Reference Books:

1. P. S. Bimbhra, "Power Electronics", Khanna Publishers
2. Ned Mohan, T.UndelandandW.Robbins, "Power Electronics Converters Applications and Design, John Willey & sons, Singapore, 2nd Edition Oxford University Press, New Delhi, 2005.

MOOC/NPTEL Courses:

NPTEL Course "Power Electronics"

1. https://nptel.ac.in/courses/108/105/108105066/
2. https://nptel.ac.in/courses/108/102/108102145/
3. https://nptel.ac.in/courses/108/107/108107128/
4. https://nptel.ac.in/courses/108/108/108108077/
5. https://batteryuniversity.com/

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering(2024Course)

PEC-362 (B) -ETC: Elective III (Robotics and Automation)

Teaching Scheme	Credits	Examination Scheme
Theory:03Hours/Week	03	**CCE*Marks:**30Marks **End Semester (Theory):**70Marks

Prerequisite Courses, if any: Students should have basic knowledge of:

- Basic Electrical and Electronic Circuits
- Digital Electronics and Logic Design
- Control Systems
- Programming Fundamentals using C/C++/Python
- Coordinate Geometry, Matrices, and Basic Engineering Mathematics

Companion Course, if any: PEC-363-section 2 Lab (**Robotics and Automation Laboratory)**

Course Outcomes: After successful completion of the course, learner will understand:

1. Principles of industrial measurement systems, focusing on the mathematical analysis of static and dynamic sensor characteristics.
2. Operation, selection, and integration of industrial actuators, fluid power systems, and high-precision electrical drives.
3. Fundamental knowledge of robotic configurations, spatial coordinate transformations, and the kinematic principles governing manipulator motion.
4. Designing automated control sequences using Programmable Logic Controllers (PLCs) and integrating them with HMI/SCADA systems.
5. Modern industrial safety standards, distributed control architectures, and the collaborative operational frameworks used in smart factories.

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

CO1: Analyze the performance of industrial transducers by calculating key static properties (linearity, sensitivity) and interpreting dynamic step responses.

CO2: Select appropriate electrical drives (servo/stepper) and fluid power components for specific automated positioning applications.

CO3: Solve homogeneous transformation matrices and apply Denavit-Hartenberg parameters to analyze forward kinematics for standard industrial robot manipulators.

CO4: Develop structured Ladder Diagram programs for PLCs to control industrial sequencing systems, object counting, and basic process loops.

CO5: Design safe industrial work cells that integrate robot-PLC communication, human-machine interfaces.

Course Contents

Unit I	Fundamentals of Industrial Measurement, Robotics and Automation	(09 Hours)

Static Characteristics: Accuracy, precision, sensitivity, linearity, resolution, hysteresis, threshold, dead zone, drift, and repeatability.

Dynamic Characteristics: Speed of response, fidelity, dynamic lag, dynamic error, and frequency response of first and second-order systems.

Introduction to Robotics: Evolution and history of robots, Laws of robotics, Types of robots: Industrial robots, Mobile robots, Humanoid robots, Collaborative robots (Cobots), Components of robotic systems, Robot anatomy and Degrees of Freedom (DOF), Coordinate systems and robot workspace.

Introduction to automation: Types of automation: Fixed automation, Programmable automation, Flexible automation, Applications in manufacturing and service industries, Introduction to Industry 4.0.		
Exemplar: Study and comparison of industrial robots used in automotive manufacturing and collaborative robots (Cobots) used in smart factories.		
Mapping of Course Outcomes for Unit I: CO1		
Unit II	**Actuators, Drives, Control Loops and End Effectors**	**(09 Hours)**
Control Architectures Open-loop vs. closed-loop systems; functional operation of Proportional-Integral-Derivative (PID) controllers. **Fluid Power Basics:** Main components of pneumatic systems (FRL unit, directional control valves, cylinders); brief contrast with hydraulic systems. **Electrical Drives:** Operational comparison of stepper motors, Brushless DC (BLDC) motors, and AC servo motors. **Mechanical Transmission:** Function of harmonic drives, ball screws, and gearboxes in removing joint backlash. **End effectors:** Mechanical grippers, Vacuum grippers, Magnetic grippers, Sensor calibration and signal conditioning, Selection criteria for sensors and actuators.		
Exemplar: Interfacing and performance analysis of IR sensor, ultrasonic sensor, servo motor, and robotic gripper for object detection and handling applications. Factory Conveyor belt, Robotic painting Systems, Machine vision Cameras		
Mapping of Course Outcomes for Unit II: CO2		
Unit III	**Robot Kinematics and Programming**	**(09 Hours)**
Introduction to robot kinematics, Joint coordinates and Cartesian coordinates Forward kinematics, Inverse kinematics basics Robot motion and trajectory planning, Point-to-point and continuous path motion. **Robot programming methods:** Lead-through programming, Teach pendant programming, Offline programming. **Introduction to Arduino/Python programming for robotics**: Motion and speed control Introduction to ROS (Robot Operating System), Safety in robotic operation		
Exemplar: Development of a simple Arduino/Python-based robotic arm movement program for point-to-point motion control and trajectory analysis.		
Mapping of Course Outcomes for Unit III: CO3		
Unit IV	**Industrial Automation and PLC Systems**	**(09Hours)**
Introduction to industrial automation systems, Open-loop and closed-loop control systems **PLC:** PLC architecture and operation, PLC hardware components, Input and output modules, Ladder logic programming basics, Timers, counters, relays, and memory operations, Sequential control systems, **Introduction to SCADA and HMI** **Industrial communication protocols:** Modbus, CAN, Ethernet/IP Industrial automation case studies		
Exemplar: Design and simulation of PLC-based automatic water level control or traffic light control system using ladder logic programming.		
Mapping of Course Outcomes for Unit IV: CO4		
Unit V	**Applications of Robotics and Automation**	**(09 Hours)**
Industrial **robotic applications:** Material handling, Welding robots, Spray painting robots, Pick-and-place robots. **Pick-and-Place Robotic System:** **Sensing Unit**: Proximity Sensor / IR Sensor, Detects object presence and position **Controller Unit:** Arduino / PLC / Embedded Controller (Processes sensor data and controls robot movement).		

Robotic Manipulator: Servo Motors with Gripper, Performs pick-and-place operation.
Automated Conveyor Belt System: Object Detection Unit: IR / Photoelectric Sensors, Detects object movement and position Control Unit: PLC with Ladder Logic, Controls conveyor sequence and timing Conveyor Drive System: DC Motor / Induction Motor, Drives conveyor movement

Mapping of Course Outcomes for Unit V: CO5

Exemplar: Case study and implementation analysis of Pick-and-Place Robotic System and Automated Conveyor Belt System used in industrial automation.

Learning Resources

Textbooks:

1. M. P. Groover, *Industrial Robotics: Technology, Programming and Applications*. New York, USA: McGraw-Hill Education, 2015.
2. S. R. Deb, *Robotics Technology and Flexible Automation*, 3rd ed. New Delhi, India: McGraw-Hill Education (India), 2010.
3. F. G. Shinskey, *Process Control Systems: Application, Design and Tuning*. New York, USA: McGraw-Hill, 2013.

Reference Books:

1. J. J. Craig, Introduction to Robotics: Mechanics and Control, 4th Edition, Pearson Education, 2018.
2. R. K. Mittal and I. J. Nagrath, Robotics and Control, McGraw-Hill Education (India), 2017.
3. W. Bolton, Programmable Logic Controllers, 6th Edition, Elsevier India, 2015.
4. A.K. Sawhney, "A Course in Electrical & Electronic Measurements and Instrumentation", Dhanpat Rai and Sons, 6th Edition-Reprinted 2022.

MOOC/NPTEL Courses:

1. NPTEL Course: Introduction to Robotics, by: Prof. Asokan T, Prof Balaram Ravindran, Prof. Krishna Vasudevan. Link: https://nptel.ac.in/courses/107106090
2. Robotics and Control: Theory and Practice, By Prof. N. Sukavanam, Prof.M.Felix Orlando, IIT Roorkee, IIT Roorkee. Link: https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_me72
3. Robotics: Basics and Selected Advanced Concepts, By Prof. Ashitava Ghosal, IISc Bangalore Link: https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_me01
4. Industrial Automation and Control, IIT Kharagpur, Prof. S. Mukhopadhyay, Prof. S. Sen, Link: https://nptel.ac.in/courses/108105062

Mechatronics and Robotics, By Dr. S. Saravana Perumaal National Institute of Technical Teachers.

Link: https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr26_ed116.

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024Course)		
PEC-362 (C) -ETC: Elective III (Artificial Intelligence)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory:03Hours/Week	03	**CCE*Marks**:30Marks **End Semester (Theory):**70Marks
Prerequisite Courses, if any:		
Companion Course, if any: PEC-363-ETC: Programme Elective Course Lab (Elective 3)		

Course Objectives:

To make students understand

1. The fundamentals of Artificial Intelligence (AI), environment and problem-solving approaches used in AI systems.
2. The search techniques like uninformed, heuristic, optimal applicable to real world AI problems.
3. The knowledge representation techniques, inference mechanisms for development of expert systems.
4. The Realization of planning, learning and analysis concept for intelligent decision support by expert systems.
5. The applications in the field of AI with knowledge of ethics for future technologies.

Course Outcomes:

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

CO1: Explain intelligent agents, environment and problem solving in AI.
CO2: Implement AI based search and optimization techniques related to real world AI problems.
CO3: Develop knowledge-based AI models with the help of inference mechanism and rule value approach.
CO4: Apply AI planning and learning techniques in the analysis of expert system towards intelligent decision making.
CO5: Assess the AI techniques for real world application along with ethical, social, and future challenges.

Course Contents		
Unit I	**Introduction to Artificial Intelligence, Intelligent Agents and Problem Solving in AI**	**(09Hours)**
Introduction: Definition and Concept of AI, History and Evolution of AI, Characteristics of Intelligent Systems, Benefits and Limitations of AI, Intelligent Agents: Definition, Structure, Types. Agents and Environments, Types of Environments: Observability: Fully Observable, Partially Observable, Predictability: Deterministic, Stochastic, Dynamics: Static, Dynamic, Continuity: Discrete, Continuous, Interaction and Agents: Single Agent, Multi-Agent, Independence of Action Sequence: Episodic, Sequential, Agent`s Knowledge: Known and Unknown Environment. Problem Solving Agents, Problem Solving Approach to Typical AI Problem, State Space Search, Search Strategies: Uninformed, Informed, Heuristics. Constraint Satisfaction Problems, Constraint Propagation, Backtracking and look ahead strategies Search.		
Exemplar: Google Assistant, Netflix, Google Map, Robotic Vaccum Cleaner, Chess, Pocker Game, Calculator, Airline Booking System.		
Mapping of Course Outcomes for Unit I:CO1		

Unit II	**Search Techniques**	**(09Hours)**

Uniformed Search Techniques: Breadth First Search (BFS), Depth First Search (DFS), Uniform Cost Search. Informed (Heuristic) Search Techniques: Best First Search, Greedy Search. Optimal Search: A* Algorithm. Heuristic Function, Generate and Test, Hill Climbing, Beam Search, Tabu Search. Constraint Satisfaction Problems (CSP), Game Playing: Minimax Algorithm, Alpha-Beta Pruning, Introduction to Reinforcement Learning Concepts, AI based Optimization Techniques.
Exemplar: Shortest Route-Finding Problem, Puzzle Problem, Social Media Friend Search, Maze solving Robot, GPS Navigation, Robot Navigation, Advanced Game Engines, Autonomous Vehicles and Robotics, Alpha Go, Robot Navigation, Airline Scheduling System.
Mapping of Course Outcomes for Unit II: CO2

Unit III	Knowledge Representation and Inference	(09Hours)
Knowledge Based Agents: Knowledge Representation, Types of Knowledge, Structured Representation of Knowledge, The Wumpus World problem, Logical Agents. Propositional Logic: Propositional Theorem Proving, Effective Propositional Model Checking, Agents Based on Propositional Logic, Predicate Logic, First Order Logic: Representation Revisited, Syntax and Semantics of First Order Logic, Knowledge Engineering in First Order Logic. Rule based Expert System, Rules. Inference Mechanism: Unification, Reasoning, Resolution, Forward Chaining, Backward Chaining Rule Value Approach. Knowledge Representation: Conceptual Dependency, Frames, Semantic nets.		
Exemplar: Amazon and Alexa, Netflix, Google Assistant, BBC Interactive News, Chatbots, IBM Watson, ChatGPT, Microsoft Copilot, Tesla Autonomous Driving AI.		
Mapping of Course Outcomes for Unit III:CO3		

Unit IV	Planning, Learning and Analysis in Expert Systems	(09Hours)
AI Planning: Block World Problem in Artificial Intelligence, Goal Tree in AI Problem Solving, Non-linear Planning for Intelligent Systems, Hierarchical Planning in AI, Goal Stack Planning Techniques. AI Learning Concepts: Definition of Learning in AI, Forms of Learning, Learning by Taking Advice, Learning in AI Problem Solving, Inductive Learning, Explanation Based Learning (EBL), Formal Learning Theory, Ensemble Learning Methods. AI Expert Systems: Intelligent Systems vs Expert Systems, Architecture of AI Expert Systems, Roles and Applications of Expert Systems, Knowledge Acquisition in AI Systems, Meta Expert System Shells. Analysis in Expert System: Knowledge Base, Inference Engine, Explanation Facility, Mechanism: Rule Matching, Handling Uncertainty, Reasoning.		
Exemplar: Automated Warehouse Robots, GPS Route Planning, Spam Email filtering, Medical Diagnosis Systems, Banking Fraud Detection, Intelligent Tutoring System, Industrial Equipment Logs to Perform Fault Diagnosis and Suggest Repairs.		
Mapping of Course Outcomes for Unit IV:CO4		

Unit V	Emerging AI Applications and Ethics	(08Hours)
AI in Natural Language Processing (NLP), Speech Recognizer, Computer Vision, Healthcare, Education, Banking and Finance, Transportation and Smart Mobility. Cyber Security, E-Commerce and Business, Social Media, Security. AI in Robotics: Robotic Sensors, Domestic Robots, Agricultural Robots, Edge AI & Tiny ML basics. Philosophy and Ethics of AI: Ethical Issues, Safety, Privacy and Surveillance, Manipulation of behavior, Bias in Decision Systems, Social Impact of AI Systems. Future AI Technologies: Explainable AI (XAI), Generative AI (Gen AI), Case Study.		
Exemplar: Digital payments, Smart Harvesting, Self Driving Cars, Smart Navigation, Green AI, Face Recognition, Chatbots, Google Translate, Smart Cities, Autonomous Assistants, Workflow Automation.		
Mapping of Course Outcomes for Unit V:CO5		

Learning Resources

Textbooks:

1. Stuart Russell, Peter Norvig, "Artificial Intelligence- A Modern Approach", Pearson Education/Prentice Hall of India, Fourth Edition, 2020.
2. Sam Bhagwat, "Principles of building AI Agents", Independently published, First Edition, 2025.
3. Patrick Henry Winston, "Artificial Intelligence", Addison-Wesley Publishing Company, Third Edition,1992.
4. Alger Fraley, "Artificial Intelligence and Generative AI Bible", Algo Ray Publishing, First Edition, 2023.
5. Paula Boddington, "Towards a code of Ehics for Artificial Intelligence", Springer International Publishing, First Edition, 2017.
6. Pete Warden, Daniel Situnayake, Frank Vahid, Tony Givargis, "Embedded System Design: A Unified Hardware/Software Introduction" Willey Publisher, First Edition, 2002.

Reference Books:

1. Saroj Kausik, "Artificial Intelligence" Cengage Learning, Second Edition, 2022.
2. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press, 1st Edition, 2005.
3. Deepak Khemani, "A First Course in Artificial Intelligence", Tata McGraw Hill Education India, 2013.
4. George F. Luger,"Artificial Intelligence: Structures and Strategies for Complex Problem Solving", Pearson Education, 6th Edition, 2008.
5. Elaine Rich, Kevin Knight and Shivshankar Nair, "Artificial Intelligence", Tata Mc-Graw Hill Education India, 3rd Edition, 2009.

MOOC/NPTEL Courses:

1. https://cse.iitkgp.ac.in/~pallab/artificial_intelligence_autumn_2020/index.html
2. http://nptel.ac.in/courses/106105077/
3. https://onlinecourses/.nptel.ac.in/noc25_cs137/preview
4. https://onlinecourses.nptel.ac.in/noc22_cs56/preview
5. https://onlinecourses.nptel.ac.in/noc23_ge40/preview
6. https://plato.stanford.edu/entries/ethics-ai/
7. https://intelligence.org/files/_EthicsofAI.pdf

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024 Course)		
PEC-362 (D) -ETC: Elective III (Industrial IoT)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	**CCE* Marks**: 30 Marks **End Semester (Theory):** 70 Marks
Prerequisite Courses, if any: Microcontroller		
Companion Course, if any: PEC-363-section 2 Lab (IIoT)		

Course Objectives:

To make students understand

1. The fundamentals of Industrial Internet of Things (IIoT), Industry 4.0 concepts, and their role in modern industrial automation systems.
2. The operation and interfacing of industrial hardware components such as sensors, actuators, controllers, PLCs, and embedded devices used in IIoT systems.
3. Industrial IoT network architectures, communication protocols, and industrial connectivity models for reliable data exchange.
4. Edge Computing and real-time data processing techniques used in smart industrial environments.
5. The role of data analytics in Industrial Internet of Things (IIoT) environments for industrial applications/case studies related to IIoT and Industry 4.0 systems.

Course Outcomes:

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

CO1: Elaborate the evolution of industrial revolutions and compare traditional industrial automation with Industry 4.0 technologies.
CO2: Implement applications of industrial sensors by understanding the working principles, characteristics.
CO3: Design the Industrial Internet Reference Architecture (IIRA), architectural viewpoints, drivers.
CO4: Analyze real-time data processing requirements in industrial environments using Edge Computing techniques.
CO5: Apply Industry 4.0 and IIoT concepts to analyze real-world industrial case studies.

Course Contents		
Unit I	**Introduction to Industrial IoT and Industry 4.0**	**(09 Hours)**
IIoT: Introduction to Industrial Internet of Things (IIoT), Design requirements of IIoT, Industrial Internet systems – Design, impact and benefits, industrial sensing, industrial processes and applications of IIoT. **Industry 4.0:** Development phases of industrial revolution, Industry 4.0 versus traditional automation, Design requirements and Drivers of Industry 4.0, Impacts and Applications of Industry 4.0, Industry 4.0 versus IIoT		
Exemplar : Industrial Machine Health Monitoring, Smart Factory Monitoring System, Smart Supply Chain		
Mapping of Course Outcomes for Unit I: CO1		
Unit II	**Hardware Components of Industrial IoT**	**(09 Hours)**

Industrial Sensors such as Proximity, pressure, temperature, flow, and vibration sensors, MEMS technology. Actuators like Stepper motors, hydraulic/pneumatic actuators, and smart valves. Signal Conditioning including Analog-to-Digital Conversion (ADC), noise filtering, and isolation techniques. Interfacing techniques, Integration with PLCs (Programmable Logic Controllers) and Distributed Control Systems (DCS).

Exemplar :
Temperature Sensor (RTD PT100), Pressure Sensor (Piezoelectric), Flow Sensor (Electromagnetic Flowmeter), Proximity Sensor (Inductive), Vibration Sensor (MEMS Accelerometer)

Mapping of Course Outcomes for Unit II: CO2

Unit III	Industrial IoT Reference Architecture	(09 Hours)

IIoT Reference Architecture (IIRA): Architectural Viewpoints, Design Drivers and Differentiating between standard IoT and IIoT architectural requirements. Layers of Industrial IoT & Functional Domains: Functional Decomposition and Five-Layer Model. Industrial IoT Network Architecture: Topology Design, Edge-Fog-Cloud Computing Model, Industrial Gateways, Mapping a typical smart factory network layout. Three-Tier IIoT **Architecture:** The Edge Tier, The Platform Tier, The Enterprise Tier, Data Flow. Gateway Mediated Edge Connectivity and Management architecture, Layered Data bus Architecture, System of Systems Architecture, IOT protocol landscape from devices to application.

Exemplar: IIC Communication and Control Testbed for Smart Microgrids, Oil and Gas Pipeline and Asset Monitoring

Mapping of Course Outcomes for Unit III: CO3

Unit IV	Edge Computing for IIoT	(09 Hours)

Concept and need of Edge Computing in Industrial IoT (IIoT) Evolution from Cloud Computing to Edge Computing. Difference between Edge Computing, Fog Computing, Cloud Computing, Characteristics and advantages of Edge Computing Real-time data processing in industrial environments.
Communication Protocol Layers in IIoT, Access & Middleware Protocols, Criteria for choosing protocols based on bandwidth, power, and latency constraints. (OPC-UA, MQTT, Modbus, PROFINET, CoAP, AMQP, BLE, LoRaWAN)

Exemplar: Think self-stocking fridges/self-driving cars, drone-delivered pizzas, Smart Factory Temperature Monitoring using Edge Computing, Conveyor Belt Fault Detection using Edge AI.

Mapping of Course Outcomes for Unit IV: CO4.

Unit V	IIOT Data Analytics and Case Studies	(09 Hours)

Introduction to Industrial Data Analytics, Data generation in IIoT systems, Data preprocessing and cleansi, Data visualization techniques, Real-time and batch analytics.
Industrial IoT- Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management. Case Study1: Milk Processing and Packaging Industries. Case Study2: Virtual Reality Lab

Exemplar: Food Industry, Agriculture Industry, Healthcare

Mapping of Course Outcomes for Unit V:CO5

Learning Resources

Textbooks:

1. S. Misra, C. Roy, and A. Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", CRC Press, 1st Edition 2020.
2. Sudan Jha, Usman Tariq, Gyanendra Prasad Joshi, and Vijender Kumar Solanki , "Industrial Internet of Things: Technologies, Design, and Applications" 1st Edition, CRC Press, 2022.
3. Hwaiyu Geng "Internet of Things and Data Analytics Handbook", Wiley Publications, 1st Edition, John Wiley & Sons, 2017.

Reference Books:

1. Misra, S., Roy, C., and Mukherjee, A." Introduction to Industrial Internet of Things and Industry 4.0" CRC Press, USA, 2020
2. R. Anandan, Suseendran Gopalakrishnan, S. Pal, N. Zaman, "Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance", Wiley-Scrivener, 1st Edition,2022.
3. Dr. Ovidiu Vermesan, dr. Peter Friess, "Internet of Things: Converging Technologies for smart environment and integrated ecosystems", River Publishers, 1st Edition,2013.

MOOC / NPTEL Courses:

1. NPTEL Course "Introduction Industry 4.0 and Industrial IoT"

https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs38

Instructions to the Students and teachers

1. Under PEC-363-ETC , Program Elective Laboratory any one subject to be chosen from Section–I and one from Section -II to be taken.
2. Total number of practicals to be performed will be 11 including 5 from Section-I and 5 from Section-II
3. One mini project either from Section-I or from Section-II should be executed which is included in the list of 11 practicals.

Section-I

PEC-363-ETC: Program Elective 2 Course Labs

(Choose any One Elective from Program Elective-2 Courses)

Program Elective II
Web Technology
Digital Image Processing
Network and Cyber Security
CMOS Process Technology

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

PEC-363(A) -ETC: Web Technology Lab

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**Term Work**: 25 **Practical:** 25 Marks

Companion Course, if any: **PEC-361-ETC Web Technology**

Course Objective:

1. To design and develop responsive and attractive web pages using modern web technologies.
2. To build interactive and dynamic web pages using client-side and server-side programming with database connectivity.
3. To develop component-based web applications using modern frameworks and development tools.

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

CO1: Design and develop responsive, attractive, and user-friendly web pages using modern web technologies.

CO2: Build interactive and dynamic web pages by integrating client-side scripting, server-side programming, and database connectivity.

CO3: Develop component-based web pages using modern frameworks and development tools.

List of Experiments

Group A: Any Three Experiments to be Performed

1. To analyze various IoT development boards and IoT platform used in IoT and Industrial IoT application.
2. Design a 'Professional Resume' using HTML elements such as headings, images, lists, tables, hyperlinks, etc. Apply an external CSS style sheet to transform its visual design.
3. Design and style a student registration form using HTML forms and CSS properties.
4. Design a student registration form with basic form validation using JavaScript
5. Design an interactive web page to demonstrate DOM manipulation and event handling using buttons, text fields, and mouse events.
6. Design a Calculator web page using jQuery to perform basic arithmetic operations such as addition, subtraction, multiplication, and division with input validation using alert/prompt messages for invalid values.

Group B: Any Two Experiments to be Performed

7. Develop a student registration web application using PHP with form handling, email validation, session tracking, file handling, and MySQL database connectivity
8. Develop a React.js application to display student information using functional components and props.
9. Create a simple student registration React.js form application with state handling and event management.
10. Demonstration of HTTPS and SSL certificate verification on websites
11. Analyze website security using online vulnerability scanners

Group C: Course Project (Any One to be performed in Group of 3 or 4 Students)

11. Analyze website SEO score using Google Search Console OR create SEO-friendly webpage using meta tags and headings.

12. Mini Project
Virtual LAB Links: Additional (min. 2) Practical's are to be performed using Virtual Lab. 1.Basics of HTML Virtual Lab (IIT Delhi) URL: https://html-iitd.vlabs.ac.in Computer Programming Lab (IIIT Hyderabad) URL:https://cse02-iiith.vlabs.ac.in 3.Cryptography Lab (IIIT Hyderabad) URL:https://cse29-iiith.vlabs.ac.in 4. Network Security Virtual Lab URL:https://ns-amrt.vlabs.ac.in
Note: 1.One practical from Group A and B should be performed as simulation practical (using any available tool). 2.Additional (min. 2) practicals are to be performed using Virtual Lab. (Optional if Virtual Labs are there)

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement
3	Brief theory related to the experiment.
4	Algorithm/Flowchart.
5	Mathematical analysis if required.
6	Conclusions
7	Mention real life examples concerned with the respective experiments
Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grades/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.
4	Program codes with sample output of all performed assignments are to be submitted as softcopy. As a conscious effort and little contribution towards Green IT and environment awareness, instead of attaching printed papers as part of write-ups, use of drive/pendrive containing student programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints in the Laboratory.
5	Use of open-source software is encouraged. Based on the concepts learned.

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024 Course)		
PEC-363 (B) -ETC Digital Image Processing Lab		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 02 Hours/Week	01	**Term Work**: 25 **Practical**: 25 Marks

Companion Course, if any: **PEC-361-ETC Digital Image Processing**

Course Objectives:

1. To introduce students to fundamental image processing techniques using MATLAB/Python/OpenCV for image acquisition, visualization, enhancement, and transformation.
2. To develop practical skills in image analysis and processing methods such as histogram processing, filtering, edge detection, thresholding, and image compression techniques
3. To enable students to implement image processing and computer vision techniques for solving real-world problems through experiments and mini-projects.

Course Outcomes:

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

CO1: Implement basic image processing operations including image reading, display, histogram analysis, enhancement, filtering, and geometric transformations using MATLAB/Python/OpenCV/Equivalent.

CO2: Analyze and apply image processing techniques such as edge detection, thresholding, spatial filtering, DCT, and performance evaluation metrics (MSE, PSNR) for image enhancement and compression.

CO3: Develop computer vision applications for image classification and pattern recognition using programming tools and real-world datasets.

List of Experiments

Group A: Any Three Experiments to be Performed
1. Perform Reading and displaying images using MATLAB/Python/OpenCV/Equivalent
2. Write a program to generate histogram for an image and plot histogram
3. Write a program to perform histogram equalization
4. Perform the following basic operations on image a. Obtain a Negative image b. Obtain the Flip image
5. Perform the following basic operations on image a. Point Detection b. Line Detection c. Edge Detection d. Thresholding
Group B: Any Two Experiments to be Performed
6 Write a program to perform various mathematical operations & logical operations on an image
7. Implement various smoothing spatial filters
8. Implement and study the effect of Different Mask (Sobel, Prewitt and Roberts)
9. Perform Block-based Discrete Cosine Transform (8X8 DCT) on an image and reconstruct the image
10. Compute and compare objective evaluation metrics (MSE, PSNR) between an original image and its lossy compressed version
Group C: Course Project **(Any One Case Study/Project to be performed in Group of 3 or 4 Students)**
11. Case Study/ Project: Handwritten Character Recognition
Note: Practicals can be performed using any MATLAB/Python/OpenCV/equivalent

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Flow Chart
3	Algorithm
4	Code
5	Test cases
6	Result
7	Conclusions
8	Mention real life examples concerned with the respective experiments
Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024 Course)		
PEC-363 (C) -ETC: Network & Cyber Security Lab		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 02 Hours/Week	01	**Term Work**: 25 **Practical**: 25 Marks
Prerequisite Courses, if any: Nil		
Companion Course, if any: **PEC-361-ETCNetwork & Cyber Security**		

Course Objectives:

1. To implement various encryption, decryption algorithms, internet security protocols, authentication and countermeasures
2. To Illustrate cyber threats, malware, system vulnerabilities, and web security issues
3. To analyze cyber laws, data privacy regulations and governance frameworks

Course Outcomes:

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

CO1: Apply encryption, decryption algorithms, authentication protocol and its countermeasures to detect threats.

CO2: Analyze the cyber threats, vulnerabilities, threats, cyber laws and government regulations.

CO3: Implement a real-life application for cyber/network security.

Group A: Any Three Experiment to be Performed
1. Write a program for Encryption and Decryption (Substitution/Transposition)
2. Implementation of Steganography and analyse its features in terms of security.
3. Perform SQL Injection Analysis and Prevention
4. Network Packet Analysis and Threat Monitoring using Wireshark
5. Password Security and Hash Cracking using John the Ripper (evaluate password strength and cracking resistance)
Group B: Any Two Experiments to be Performed
6. Network Packet Analysis and Threat Monitoring using Wireshark (TCP 3-way handshake, DNS lookup, ARP, HTTP vs HTTPS, Packet fragmentation)
7. Perform active reconnaissance and vulnerability identification and Port Scanning using Nmap
8. Write a Program to implement Asymmetric Key Cryptography (RSA/DiffieHelmon)
Group C: Course Project/Case study (any 1 to be performed in Group of 3 or 4 Students)
9. Case Study Based Cybersecurity Problem Solving using CyLab Security Academy (Formerly picoCTF).
10. Project: Cyber Ethics and Data Privacy Risk Assessment

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement
3	Ckt/Logic Design of given problem statement
4	Diagram with theory for operation
5	Experimentation
6	Observation/ Result table
8	Conclusions

9	Mention real life examples concerned with the respective experiments
Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, understanding, Participation in experiment conduction and post experiment skills

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

PEC-363 (D) -ETC: CMOS Process Technology Lab

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**Term Work**: 25 **Practical**: 25 Marks

Companion Course, if any: **PEC-361-ETC: CMOS Process Technology**

Course Objectives:

1. Simulate and analyze CMOS inverter, logic gates, and combinational circuits including MUX and adders using SPICE/Equivalent tools.
2. Develop and verify CMOS layout designs for logic circuits following standard VLSI layout design rules.
3. Implement a CMOS design project using open-source EDA/Equivalent tools.

Course Outcomes:

CO1. Simulate and analyze CMOS logic circuits using SPICE/Equivalent tools.

CO2. Design CMOS combinational circuits and develop their layouts following VLSI design rules.

CO3. Design and optimize CMOS VLSI circuits and investigate technology scaling trends

List of Experiments

Group A: Any three Experiments to be Performed

1. CMOS Inverter Characteristics using SPICE/any other equivalent tool.
2. CMOS NAND and NOR Gate Simulation.
3. CMOS based 2:1 MUX Simulation
4. TG based 2:1 MUX Simulation

Group B: Any Two Experiments to be Performed

5. CMOS Inverter Layout Design
6. NAND and NOR Layout Design
7. CMOS Layout Design of Half Adder
8. CMOS Layout Design of Full Adder
9. Layout Design of 2:1 Multiplexer using CMOS and Transmission Gate

Group C: Course Project (anyone to be performed in Group of 3 or 4 Students)

10. Project by Students-Selected CMOS Design Implementation
11. CMOS Process Technology Scaling - 180nm to 5nm
12. FinFET Technology - From Planar to 3D Transistors

Virtual LAB Links:

1. **IIT Kharagpur Virtual Labs** https://vlabs.iitkgp.ac.in/
2. **Nano hub**:https://nanohub.org/groups/semiconductors/semiconductortools

Note:

1. One practical from Group A and B should be performed as simulation practical (using any available tool).
2. Additional (min. 2) practicals are to be performed using Virtual Lab. (Optional if Virtual Labs are there).

Guidelines for Students Lab Journal	
1.	Title of the experiment
2.	Problem Statement
3.	Ckt/Logic Design of given problem statement
4.	Diagram with theory for operation
5.	Experimentation
6.	Observation/ Result table
7.	Conclusions
8.	Mention real life examples concerned with the respective experiments
Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality and Neatness.

PEC-362-ETC Program Elective 3-Courses
(Choose any One Elective from Program Elective-3 Courses)

Program Elective-III
Power Electronics
Robotics and Automation
Artificial Intelligence
Industrial IOT

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024Course)

PEC-362 (A) -ETC: Power Electronics Lab

Teaching Scheme	Credits	Examination Scheme
Practical:02Hours/Week	01	**TermWork**:25 **Practical**:25Marks

Companion Course, if any: **PCC-362-ETCPower Electronics**

Course Objectives:

1. To familiarize students with the operating characteristics and practical behavior of power semiconductor devices such as SCR, MOSFET, and IGBT.
2. To develop the ability to analyze, implement, and test basic power electronic converters and motor control circuits using suitable loads.
3. To provide hands-on experience in simulation, measurement, waveform analysis, and performance evaluation of power electronic systems.

Course Outcomes:

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

1. Perform and analyze the V-I characteristics and switching behavior of power semiconductor devices such as SCR, MOSFET, and IGBT.
2. Implement and evaluate the performance of AC voltage controllers, inverters, choppers, and motor control circuits using power electronic devices.
3. Utilize simulation tools and laboratory practices to design, test, document, and troubleshoot basic power electronic applications effectively.

List of Experiments

Group A: Any Three Experiments to be Performed

1. V-I Characteristics of SCR i) Plot-I characteristics to measure I_H, I_L and voltage before and after breakdown ii) Observe the effect of gate current on forward break down iii) Gate characteristics

iv) Compare with datasheet specifications.

2 .V-I Characteristics of Power MOSFET i) Plot characteristics and calculate output Resistance ii) Plot transfer characteristics and measure threshold voltage iii) Compare with datasheet specifications.

2. V-I Characteristics of IGBT, Plot output characteristics and calculate output resistance

ii) Plot transfer characteristics and measure threshold voltage iii) Compare with datasheet specifications.

4. Single phase AC voltage controller using IGBT/SCR for R and RL Load i) Observe output rms voltage waveforms, ii) Measurement output voltage across load, iii) Verification of theoretical

values with practically measured values.
5.Single-Phase PWM Power MOSFET / IGBT based bridge inverter for R and motor load i) Observe output voltage waveforms and measure set of rms output voltage for varying pulse width and variable input dc voltage for R and motor load ii) Compare measured output voltages with the Theoretical findings.
6.Step down/Step up chopper using power MOSFET/IGBT i) Measure duty cycle and observer effect on average load voltage for DC chopper.
Group B: Any Two Experiments to be Performed
7. SMPS/UPS Performance Evaluation i) Find load and line regulation characteristics for no load and full load condition and at 500 mA and 1A load ii) Compare the performance with supplier specifications.
8. Simulation of the Single-phase AC voltage controller using Powersim / any open-source circuit simulation software
9. To study speed control of DC/single phase AC motor
Group C: Course Project/Case study (Anyone to be performed in Group of 3 or 4 Students)
10 Case study on solar cell operated emergency lighting system 11 Case Study on Electric Vehicle
Virtual LAB Links: **Power Electronics:** 1. https://pe-iitr.vlabs.ac.in/List%20of%20experiments.html 2. https://pe2-iitd.vlabs.ac.in/List%20of%20experiments.html 3. https://pe1-iitd.vlabs.ac.in/List%20of%20experiments.html

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement
3	Ckt/Logic Design of given problem statement
4	Diagram with theory for operation
5	Experimentation
6	Observation/ Result table
7	Graphs if any
8	Conclusions
9	Mention real life examples concerned with the respective experiments
Guidelines for Laboratory/Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory Performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.

3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

PEC-362 (B)–ETC: Robotics and Automation Lab

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**Term Work:** 25 **Practical:** 25 Marks

Companion Course, if any: **PEC-362-ETCRobotics and Automation**

Course Outcomes:

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

CO1: Interface and operate various sensors, actuators, robotic controllers, and PLC systems used in robotics and industrial automation applications.

CO2: Develop and implement basic robotic systems such as obstacle detection robots, line follower robots, and sensor-based autonomous control systems.

CO3: Design and analyze industrial automation solutions using PLCs for applications such as water level monitoring and control, conveyor automation, and process control systems.

List of Experiments

Sr. No	Problem Statement
	Group A: Any Three Experiments to be Performed
1	Calibration and Evaluation of Static Characteristics (Linearity, Hysteresis, and Sensitivity) of an Industrial Load Cell Strain Gauge.
2	Implement and demonstrate servo motor control for a single-link robotic arm to analyze rotary joint movement and angular displacement characteristics.
3	Develop and test a line following mobile robot using IR sensors and DC motor control for autonomous navigation and differential drive operation.
4	Develop a PLC-based automatic water level controller using ladder logic, relay control, and level sensing for process automation.
5	Implement traffic signal automation using PLC timers, counters, and sequencing logic for industrial control system applications.
6	Design and implement an automated conveyor belt control system using industrial sensors, motor control, and sequential automation techniques.
	Group B: Any Two Experiments to be Performed
7	Analyze and implement forward kinematics of a two-link planar robotic arm using revolute joints and degree of freedom (DOF) concepts for robotic motion analysis.
8	Design and implement a pick-and-place robotic manipulator using gripper mechanisms, linkage systems, and joint motion analysis.
9	Design and implement an automated conveyor belt control system using industrial sensors, motor control, and sequential automation techniques.
10	Develop and test a line following mobile robot using IR sensors and DC motor control for autonomous navigation and differential drive operation.
	Group C: Course Project (Any One Case study to be done in the Group of 3 or 4 students
1	**Case Study:** Pick-and-Place Robot in Manufacturing Industry: Robot structure, kinematics, motion planning, industrial robotics
2	**Case Study:** Automated Conveyor System in Packaging Industry: PLC architecture,

	conveyor synchronization, industrial automation

Virtual LAB Links:

1. Mechatronics System Design Lab: https://msd- coep.vlabs.ac.in/?utm_source
2. Programmable Logic Controller: https://plc-coep.vlabs.ac.in/?utm_source
3. Yukti Robotics: Build Hardware Smarter: https://yuktirobotics.in/?utm_source
4. Ayantrik Lab: Virtual Electronics Lab India: https://ayantrik.in/virtual-electronics-lab-india?utm_source

Note:

Simulation is an alternative for hardware experimentation and not a replacement for practical implementation. Institutes not having all the required hardware setups may conduct suitable experiments using virtual laboratories, simulation, emulation, or software tools. Use of any specific tool is not mandatory; however, exposure to modern engineering tools and industry practices should be ensured.Institutes may plan or modify experiments based on available infrastructure while ensuring that the required knowledge, practical skills, and industry readiness are achieved.

Additionally, any one case study shall include either: a visit to a relevant industry, **OR** development of an institute-level system/prototype with performance analysis.

Suggested Free Simulation / Emulation Tools for Robotics and Automation Experiments

Tool	Suitable Experiments	Key Features	Platform
Tinkercad Circuits	Servo motor control, line follower robot, sensor interfacing, Arduino-based robotics	Online Arduino simulation, circuit design, servo/DC motor simulation, easy programming	Web-based
Wokwi Simulator	Arduino robotics, ultrasonic sensors, IR sensors, servo motor experiments	Fast Arduino/ESP32 simulation with sensors and motors	Web-based
OpenPLC Editor	PLC water level controller, traffic signal automation, conveyor automation	Free PLC ladder logic programming and runtime environment	Windows/Linux
Factory I/O (Trial Version)	Conveyor automation, industrial automation systems	Industrial automation simulation with PLC integration	Windows
CoppeliaSim EDU	Robotic arm kinematics, pick-and-place robot, mobile robot simulation	Advanced robot simulation, kinematics, sensors, motion planning	Windows/Linux
Gazebo Simulator	Autonomous robots, robot navigation, ROS-based experiments	Realistic robotics simulation with physics engine	Linux/Ubuntu
ROS (Robot Operating System)	Robot programming, navigation, robot motion control	Open-source robotics middleware and simulation integration	Linux
FreeCAD with Robot Workbench	Linkages, robotic arm design, joint analysis	Mechanical design and kinematic analysis	Windows/Linux
ScilabXcos	Control systems, automation logic, motor response analysis	Free alternative to MATLAB/Simulink	Windows/Linux
Proteus Demo Version	Sensor interfacing, embedded robotics, motor control	Electronics and microcontroller simulation	Windows

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement, Objectives, expected Outcomes
3	Logic Design, calculations of given problem statement
4	Block/ Logic/ Interface diagram with connections and major components model numbers
5	Observation table/Truth table
6	Test cases
7	Result table and appropriate graphs if any
8	Conclusions

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024Course)		
PEC-362 (C)– ETC: Artificial Intelligence Lab		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 02 Hours/Week	01	**Term Work**: 25 Marks **Practical**: 25 Marks
Companion Course, if any: **PEC-362-ETC: Artificial Intelligence**		

Course Outcomes:

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

CO1: Design and implement solutions for constraint satisfaction problems using backtracking and constraint propagation.

CO2: Apply rule-based systems and search techniques (DFS, BFS, A*) to solve structured problem-solving task.

CO3: Develop intelligent agents for decision making in games using Minimax and Greed based first search techniques.

List of Experiments

Group A: Any Three Experiments to be Performed
1. Develop a solution for Constraint Satisfaction Problem (CSP) of an Expert System that provides simple decision-making using Python/Open-Source.
2. Implement a Constraint Satisfaction Problem (CSP) solution for solving real world problems like Map Coloring, Sudoku or Timetable scheduling using backtracking with constraint propagation.
3. Implement AI Search Techniques (DFS, BFS) for 8-Puzzle problem using Graph Search Algorithm
4. Implement Greed Based First Search for Map based problem using Python/Open-source.
5. Implement A* algorithm for an application to solve AI search problems.
6. Implement Minimax algorithm for game playing.
7. Perform parsing of family tree using knowledge base.
Group B: Any Two Experiments to be Performed
8. Implement Forward chaining algorithm or Backward chaining algorithm using Python/Open-Source.
9. Implement basic search strategies: 8- Queens Problem.
10. Implement Tic Tac Toe game using minimax algorithm using Python/Open-Source.
11. Create a chatbot application for any real-world scenario.
Group C: Course Project (Any One Case study to be done in the Group of 3 or 4 Students))
12. Case Study on Practice of SORA/Practice of ChatGPT and its usage.
13. Case Study on Practice of AI Image Generator/ Practice of Prompt Engineering to craft effective prompts.
14. Open Ended Assignment using Agentic AI/Gen AI.

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

PEC-362 (D)– ETC: Industrial IoT Lab

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**Term Work**: 25 **Practical**: 25 Marks

Companion Course, if any: **PEC-362-ETCIndustrial IoT**

Course Outcome:

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

CO1: Interface an IIOT hardware component with an appropriate driver and implement embedded programs for precise control of motion control parameters.
CO2: Design and implement an Industrial IoT communication system using communication protocols.
CO3: Evaluate an Industrial IoT architecture that integrates distributed communication technologies and IIRA viewpoints to address industrial challenges.

List of Experiments

Group A: Any Three Experiments to be Performed

1. Interface a bipolar stepper motor with a dedicated driver (e.g., A4988 or an industrial driver). Write a program to control acceleration, deceleration, exact angular position, and rotation speed.
2. Create a logic sequence where the stepper motor drives a belt or index table, stopping precisely at a station when a proximity sensor detects a specific material type.
3. Smart Home Automation Using Sensors with Tinkercad.

Group B: Any Two Experiments to be Performed

4. Identify suitable protocols for industrial scenarios such as: Smart factory, Predictive maintenance, Remote monitoring, Asset tracking based on Bandwidth, Power requirement, Latency, Communication range and Reliability.
5. Develop an Industrial IoT communication system using the MQTT protocol where one IoT device publishes industrial sensor (Temperature / Humidity / Vibration sensor) data and another device subscribes to the data for real-time monitoring and analysis to demonstrate the reliable machine-to-machine communication using an MQTT broker.
6. Develop a Python-based Industrial IoT analytics system that reads sensor data such as temperature, humidity, vibration, or pressure from a CSV file. Performs data preprocessing, statistical analysis (Mean calculation, Maximum and minimum values, Standard deviation, Moving average analysis), and graphical visualization (Temperature vs Time, Humidity vs Time, Vibration trend graph).

Group C: Course Project (Any One Case study to be done in the Group of 3 or 4 Students)

7. Case Study/ Project: Design and Analysis of IIC Communication and Control Testbed for Smart Microgrids using IIRA Viewpoints, Three-Tier Deployment, and Interoperability Framework
8. Case Study/ Project: Design of an Industrial Case study using IIRA Architecture, Design Drivers and Distributed Data Communication.
   a. A clear Domain mapping table showing Control Domain vs. Information Domain data boundaries
   b. Detailed pipeline layout specifying Edge gateway processing vs Cloud ingestion hubs.
   c. Resolve multi-vendor integration through standardized transport layer protocols.

YouTube Link: https://www.youtube.com/watch?v=6Xi6qZHl7ws **(Experiment 3)**

Note:

1. One practical from Group A and B should be performed as simulation practical (using any available tool).

Additional (min. 2) practicals are to be performed using Virtual Lab. (Optional if Virtual Labs are there)

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Problem Statement
3	Ckt/Logic Design of given problem statement
4	Diagram with theory for operation
5	Experimentation
6	Observation/ Result table
7	Graphs if any
8	Conclusions
9	Mention real life examples concerned with the respective experiments
Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

MDM-371-ETC: Database Management system

Teaching Scheme	Credits	Examination Scheme
Tutorial: 01 Hours/Week	01	**Term Work:**25 Marks **Oral:** 25 Marks

Prerequisite Courses: Data Structures and Algorithms, Object oriented programming

Companion Course, if any: Database Management system Laboratory

Course Outcomes:

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

CO1: Explain the fundamental concepts of database management systems, including data models, ER/EER modelling, and relational database design principles.
CO2: Design relational database schemas and write structured SQL queries to create, modify, filter, and aggregate data according to business requirements.
CO3: Apply advanced SQL techniques including join operations, transaction control, security commands, and cursors for efficient data retrieval.
CO4: Design and manage stored procedures, functions, and triggers with robust exception handling.
CO5: Evaluate different NoSQL database models and their applications in managing large scale & unstructured data systems.

Course Contents

Unit I	Introduction to Database Management System	(03 Hours)

Introduction to Database Management Systems, Importance of Relational Database Systems, Database System Applications.
Relational Model: Structure of relational databases, Domains, Relations, Keys: Super key, Candidate key, Primary key, foreign key, Relational algebra – fundamental operators and syntax, relational algebra queries, Normalization & Codd's Rule,
Entity-Relationship model: Basic Concepts, Entity Set, Relationship Sets and Weak Entity Sets, Mapping Cardinalities, E-R diagrams Extended E-R Features, Converting E-R & EER diagram into tables.

Exemplars: Real Time examples of Railway/Bus/Aeroplane/Reservation Systems/Hospital Management Systems/Examination Systems etc.

Mapping of Course Outcomes for Unit I: CO1

Unit II	Basics of SQL	(03 Hours)

Introduction to SQL, features and advantages of SQL, types of SQL commands (DDL, DML, DQL, DCL TCL), SQL data types and literals, SQL constraints, database creation, table creation and modification, SQL commands such as CREATE, ALTER, DROP & TRUNCATE, data manipulation using INSERT, UPDATE, and DELETE, data retrieval using SELECT statement, filtering data using WHERE clause, SQL operators, sorting data using ORDER BY, pattern matching using LIKE, handling null values, aggregate functions (COUNT, SUM, AVG, MIN, MAX), grouping data using GROUP BY and HAVING.

Exemplar : Creating databases and tables, applying SQL data types and constraints, executing DDL and DML commands, writing queries using SELECT, WHERE, and ORDER BY

Mapping of Course Outcomes for Unit II: CO2

Unit III	Transactions & SQL Joins Operations	(03 Hours)

Introduction to Relational Databases, Need for Joins in DBMS, Cartesian Product (Cross Join), Inner Join, Left Outer Join, Right Outer Join, Full Outer Join, Natural Join, Self Join, Joining Multiple Tables, Join Operations with WHERE Clause, Transaction & its ACID Properties, Transaction control commands (COMMIT, ROLLBACK, SAVEPOINT), SQL security commands (GRANT, REVOKE), Applications of SQL Joins. **Cursors:** Introduction to Cursors, Types of Cursors: Implicit and Explicit. Cursor operations: Declare, Open, Fetch, and Close. Cursor attributes (%FOUND, %NOTFOUND, %ROWCOUNT, %ISOPEN), Parameterized cursors and Cursor FOR loops, Applications of cursors.

Exemplar: Design and implement a Library Management System database to demonstrate SQL joins, transaction control, security commands, and cursor-based report generation.

Mapping of Course Outcomes for Unit III: CO3

Unit IV	PL/SQL Programming	(03 Hours)

Stored Procedures & Stored Function: Introduction and advantages of Stored Procedures. Creating, executing, modifying, and deleting procedures. Use of variables, exception handling, and nested procedures. Introduction to Stored Functions and comparison with Procedures. Creating functions with parameters and return values. **Trigger:** Introduction and purpose of Triggers. Types of Triggers: DML, DDL, and Database Triggers. BEFORE, AFTER, and INSTEAD OF triggers. Statement-level and Row-level triggers. Use of OLD and NEW references, Applications in auditing, data integrity and security.

Mapping of Course Outcomes for Unit IV:CO4

Unit V	Non-SQL Database	(03 Hours)

Types of Data: structured, unstructured and semi structured data. NoSQL Database: Introduction, need, features. **Types of NoSQL Databases:** Key Value store, Document store graph, wide column store, BASE properties, DATA consistency model, ACID vs BASE MongoDB (with syntax and usage): CRUD operations, Indexing, Aggregation, Map Reduce, Replication, Sharding. **Case Study:** Study NoSQL Database Selection for a Social Media Platform

Mapping of Course Outcomes for Unit V:CO5

Learning Resources

Textbooks:

1. A. Silberschatz, H.F. Korth and S. Sudarshan, Database System Concepts, McGraw Hill, 7th Edition, 2019, (McGraw Hill).
2. C.J. Date, A. Kannan, S. Swamynathan: An introduction to Database Systems, Pearson, 8th Edition,2003 (Pearson).

3. Pramod Sadalage and Martin Fowler NoSQL Distilled, Addison-Wesley Professional

Reference Books:

1. Steven Feuerstein, "Oracle PL/SQL Programming", O'Reilly Media, Latest Edition.
2. Thomas Connolly and Carolyn Begg, "Database Systems: A Practical Approach to Design, Implementation, and Management", Pearson Education, 6th Edition.
3. Ramez Elmasri and Shamkant B. Navathe, "Fundamentals of Database Systems", Pearson Education, 6th Edition.

MOOC / NPTEL Courses:

1. Database Management System, IIT Kharagpur by Prof. Partha Pratim Das, Prof. Samiran Chattopadhyay
   Link: https://nptel.ac.in/courses/106105175

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering (2024 Course)

MDM371-ETC: Database Management System Lab

Teaching Scheme	Credits	Examination Scheme
Practical: 02 Hours/Week	01	**Term Work:** 25 Marks **Oral:** 25 Marks

Companion Course, if any:

Course Objectives:

1. **To Formulate and Implement Relational Database Concepts:** To enable students to translate real-world problem statements into Entity-Relationship (ER) models and map them efficiently into relational schemas using structured Data Definition (DDL) and Data Manipulation (DML) languages.
2. **To Develop Advanced Database Programming Skills:** To train students in optimizing transactional database environments by writing procedural logic using PL/SQL features like stored functions, explicit triggers, and data cursors.
3. **To Explore Distributed and Document-Oriented Systems:** To introduce non-relational database principles (NoSQL) using MongoDB, focusing on unstructured data storage, CRUD workflows, advanced structural indexing, aggregation frameworks, and analytical Map-Reduce paradigms.

Course Outcome:

CO1: Design and Query Relational Databases (Group A): Formulate normalized database architectures via structural ER diagrams and extract target data profiles by executing complex multi-table joins, conditional aggregations, and subqueries.

CO2: Build Automated and Programmatic Control Systems (Group B): Implement server-side automation scripts, background business auditing loops, and systematic transactional workflows within database engines using native PL/SQL extensions and modern NoSQL aggregations.

C03: Design, implement, and automate domain-specific database systems (Group C) such as Library, Railway, or Movie Booking systems) by mapping real-world business requirements into normalized relational schemas, executing multi-table transactional queries, and deploying programmatic SQL logic like triggers for real-time data automation.

List of Experiments

Group A: Any Four to be Performed (1,2 & 3 is Compulsory)

1.Preparation of ER diagram of any case study/Example which consist of RDBMS Structure

2. Design and Execute Use DDL instructions and take any five examples to understand the concept.

3. Design and Execute SQL queries for given database applications using SQL Data Manipulation Language (DML) statements: Insert, Select, Update and Delete.

4.Perform basic SQL join operations (INNER JOIN, LEFT JOIN, RIGHT JOIN CROSS JOIN, SELF JOIN and NATURAL JOIN) to retrieve and analyze data from related database tables. (Any Five Commands)

5.Develop multi-table SQL queries using joins, aggregate functions, GROUP BY, and HAVING clauses to solve real-world database problems

Group B: Any Four to be Performed

6. Create a function to calculate salary, grade, or fine based on input values. Use function in SQL SELECT statement.

7. Retrieve and display records of employees/students using explicit cursor. Write an explicit cursor to fetch and display all records. Use cursor attributes (%FOUND, %NOTFOUND, %ROWCOUNT).
8.Create a trigger to update the stock/salary/audit table automatically on INSERT/UPDATE/DELETE
9. Mongo DB queries: Design and Develop Mongo DB Queries using CRUD operations. (Use CRUD operations, SAVE Method and logical operators)
10. Mongo DB – Aggregation and Indexing: Design and Develop Mongo DB Queries using Aggregation and indexing with suitable examples.
11.Mongo DB Map reduces operations: Implement Map reduces operation with suitable example using Mango DB
Group C: Course Project (Any one) Group of 3/4 Students
12. To study, design, and implement a database-driven Library Management System for managing book records, member details, issue-return transactions, and fine calculations efficiently using DBMS concepts and SQL operations.
13. To study and design a Railway Reservation Database Management System for managing train schedules, passenger information, ticket booking, cancellations, and seat allocation efficiently using DBMS concepts.
14. To study and design a Movie Ticket Booking Management System for efficient handling of movie schedules, seat reservations, customer booking records, and payment management using database management
Additional Recourses Links: **Leet-Code (- The World's Leading Online Programming Learning Platform** **OR Any Other Suitable Online Platform**

Guidelines for Students Lab Journal	
1	Title of the experiment
2	Aim/Objectives
3	Problem Statement
4	Database Schema/Table Structure
5	SQL Queries/PLSQL Code
6	Output/Screenshot
7	Observation
8	Result/Conclusion
9	Real-world Application
Guidelines for Laboratory / Term Work Assessment	
1	Continuous assessment of laboratory work based on overall performance and laboratory performance of students.
2	Each laboratory assignment assessment should assign grade/marks based on parameters with appropriate weightage.
3	Suggested parameters include timely completion, performance, efficiency, punctuality, and neatness.
4	Installation of SQL (MySQL Workbench)/Any other SQL Software need to be done

Savitribai Phule Pune University
Third Year of Electronics and Telecommunication Engineering(2024Course)

MDM-372-ETC
Course Name: Mini Project

Teaching Scheme	Credits	Examination Scheme
Theory:02Hours/Week	01	**TermWork**:50 Marks

Prerequisite Courses, if any:
1. Digital Electronics
2. Electronics Circuits
3. Electronics Skill Development Lab

Companion Course, if any: Nil

Course Objectives:
1. To provide industry-oriented technical skills relevant to modern Electronics and Telecommunication industries.
2. To enhance practical knowledge in embedded systems, IoT, PCB design, industrial automation, FPGA/VLSI and communication systems.
3. To develop vocational and employability skills through hands-on training and mini projects.
4. To improve problem-solving, teamwork, communication skills.
5. To bridge the gap between academic learning and industrial requirements.

Course Outcomes:

On completion of the course student will be able to

CO1: Identify and select an appropriate problem statement for a mini project considering industrial requirements and practical applications
CO2: Develop the ability to understand, plan, and implement a team-based mini project by following industrial Practices and safety standards relevant to the Electronics and Telecommunication (E&TC) industry.
CO3: Design and implement embedded and IoT-based applications.
CO4: Develop PCB layouts and troubleshoot electronic systems.
CO5: Analyze and test the miniproject rigorously.
CO6: Demonstrate vocational, teamwork, presentation, and entrepreneurship skills through projects.

A) Execution of Mini Project

1	Project group shall consist of not more than 3 students per group.
2	Mini Project Work should be carried out in the Design / Projects Laboratory.
3	Project designs ideas can be necessarily adapted from recent issues of electronic design magazines.
4	Use of Hardware devices/components is mandatory.
5	Schematic-to-layout validation shall be carried out.
6	PCB bare board validation report shall be generated.
7	Assembly of components and enclosure design is mandatory.

B) Selection: Domains for projects may be from the following, but not limited to:

1	Instrumentation and Control Systems
2	Electronic Communication Systems

3	IoT
4	Embedded Systems
5	Power Electronics
6	Mechatronic Systems
7	Microcontroller based projects should preferably use Microchip PIC controllers / ATmega controller / AVR microcontrollers/ Rasberry Pi.
8	Biomedical Electronics
9	FPGA/VLSI
C) Monitoring: (for students and teachers both): Suggested Plan for various activities to be monitored by the teacher.	
Week 1 & 2:	Formation of groups, Problem identification and Finalization & Distribution of work.
Week 3 & 5	PCB design using an appropriate EDA tool, design fundamentals and standards, Schematic capture and PCB layout tools, Soldering, testing, and troubleshooting (Two days PCB design workshop).
Week 6 to 9	Arduino based smart industry-based applications using various communication protocols, IoT architecture and cloud connectivity using various IOT Platforms.
Week 10 &11	Testing of final product, Preparation, Checking & Correcting of the Draft Copy of Report
Week 12	Demonstration and Group presentations. Log book for all these activities shall be maintained and produced at the time of examination.
D. Report writing: A project report with following contents shall be prepared:	
1	Title page
2	Acknowledgement
3	Abstract
4	Table of Content
5	Introduction
6	Problem Statement Objective
7	Literature survey
8	Methodology with block diagrams & Design calculation circuitdiagram , Product Enclosure Development
9	Implementation of project
10	Result & discussion, Future Scope
11	Conclusion, References
12	Bill of Material (BOM) with cost
13	Schematic Diagram, PCB Layout
14	Test Results with Conclusion

Textbooks:

1. Programming Arduino: Getting Started with Sketches — Simon Monk, McGraw-Hill TAB, 3rd Edition.
2. Arduino Cookbook — Michael Margolis, O'Reilly Media, 3rd Edition.
3. Internet of Things — Raj Kamal, McGraw-Hill Education, 1st Edition, 2017

Reference Books:

1. Embedded Systems - SoC, IoT, AI and Real-Time Systems — Raj Kamal, McGraw-Hill Education India, 4th Edition, 2020.

2. Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards — Simon Monk, McGraw-Hill Education TAB, 1st Edition, 2014.
3. Industrial Electronics and Control — S. K. Bhattacharya & S. Chatterjee, McGraw-Hill Education, 1st Edition 2019.
4. Embedded Realtime Systems Programming — Iyer & Gupta, McGraw-Hill Education India, 1st Edition, 2003.

MOOC/ NPTEL Courses:

NPTEL Courses Portal

Recommended Courses:

1. https://onlinecourses-archive.nptel.ac.in/noc18_cs05/preview
   https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ee168 https://onlinecourses-archive.nptel.ac.in/noc18_cs05/preview SWAYAM Platform
   Useful for:
2. https://onlinecourses.swayam2.ac.in/e-learning/preview/aic20_sp04
   https://swayam.gov.in/explorer?category=Engineering_and_Technology

Savitribai Phule Pune University Third Year of Electronics and Telecommunication Engineering (2024 Course)		
ELC-381-ETC-Internship		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 08 Hours/Week	04	**Oral:** 50Marks

Course Objectives:

The course aims to:

1. To expose students to real-world industry practices.
2. To bridge the gap between academic learning and practical implementation.
3. Develop professional competency, ethics, communication, and teamwork skills.
4. To encourage self-learning and problem-solving abilities.
5. Encourage innovation, entrepreneurship, and research aptitude.

Course Outcomes:

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

CO1: Apply theoretical knowledge to solve real-world engineering problems. CO2: Demonstrate technical competency in tools/technologies used in industry.

CO3: Exhibit professional ethics and teamwork.

CO4: Prepare technical reports and deliver effective presentations on industrial training experience.

CO5: Analyze industrial processes and suggest feasible improvements or innovations.

Guidelines

1. Students should opt for a internship/JOT that would provide them to gain ample field knowledge in the relevant field of engineering such that theoretical knowledge gained in the class can be applied to solve the practical/ field problem.
2. Students must have to opt for technical internship (minimum 100 hrs.) after V semester and before VI semester, commencement preferably during winter break (December & January).
3. Undergoing a training programme / Course at a particular organization for specified duration is NOT considered as summer internship
4. However, student can attend such programs mentioned in above to learn new tools for short duration that would help for solving the problem undertaken in the internship
5. Students should take a challenging task, may be a small portion, and apply the knowledge

gained to solve it.

6. Internship can also involve data collection from different sources, including generating experimental data, collection of data from field etc. The data may be analyzed later on.
7. Different central and state government organizations, CSIR labs, premier institutions like IITs and IIMs, DRDO, public sector undertaking organizations, top IT companies may be considered for internships.
8. Student need to submit Synopsis, Permission letter and offer letter to Internship coordinator before proceeding to internship.
9. Internshipcompletionwillbeconsideredonlyaftersubmissionofvaliddocumentsattheend of internship like Completion certificate, Report and presentation of work done, feedback from industry etc.
10. Student will appear for term work evaluation where he/she will present the work done before mentor(s) at the end of internship.

Suggested Internship Activities

- Studentsareexpectedtoperformthefollowingactivitiesduringinternship:

Phase I–Orientation and Requirement Study

-Understanding organization structure
-Study of workflow and operational processes
-Requirement analysis and project allocation
-Understanding tools and technologies used

Phase II–Technical Learning and Development

-Coding/implementation of hardware design

- Selection of inputs/ sensors/ Database design

- Hardware/ Software testing and debugging

- Integration of design and deployment

- Specification Documentation

Phase III–Project Execution

- Module development
- Testing and validation
- Performance optimization
- Customer /Client interaction (if applicable)
- Team collaboration

Phase IV–Documentation and Presentation

- Preparation of internship report
- Preparation of project demonstration

- Final presentation and viva-voce.

Deliverables

- Internship Joining Report
- Weekly Logbook
- Mid-term Progress Report
- Supervisor Feedback (Initial)

Internship Structure

The internship maybe carried out in anyone of the following domains:

- Software Development
- Artificial Intelligence and Machine Learning
- Data Science and Analytics
- Cloud Computing and DevOps
- Cyber Security
- Web and Mobile Application Development
- IoT and Embedded Systems
- Networking and System Administration
- Automation and Robotics Software
- Research and Development
- Entrepreneurship and Startup Projects
- Government/NGO Technical Projects

Nature of Internship

Students shall undergo internship/training in one of the following:

- Registered companies/startups
- Government organizations
- Research institutions
- Recognized industry-academic collaborative projects
- Internships may be conducted in offline, online, or hybrid mode, subject to proper approval and verification.

Writing Learning Resources

1. W. J. King and James G. Skakoon, The Unwritten Laws of Engineering, Second edition, ASMEPress,2019.
2. Stuart Walesh, Engineering Your Future: The Professional Practice of Engineering, John Wiley & Sons, 3rd edition, 2012.

3. Eliyahu M. Goldratt, "The Goal: A Process of Ongoing Improvement", 40th edition 2024, North River Press.
4. AICTE Internship policy: AICTE Internship Policy: Guidelines & Procedures.
AICTE Internship Portal: https://internship.aicte-india.org

Guidelines for Internship Report

1. Preliminary Pages
   - Cover Page
   - Certificate from Organization
   - Certificate from Department
   - Acknowledgement
   - Abstract
   - Table of Contents
2. Chapter1–Organization Profile
   - Company overview
   - Vision and mission
   - Products/services
   - Organizational structure
3. Chapter2–Problem Statement and Objectives
   - Project title
   - Need of project
   - Objectives
   - Scope
4. Chapter3–Technologies and Methodology
   - Software/hardware tools used
   - Development methodology
   - System architecture
   - Database design/ sensors
5. Chapter4–Work Carried Out
   - Tasks completed
   - Screenshots/results
   - Challenges faced
   - Solutions implemented
6. Chapter5–Learning Outcomes
   - Technical learning
   - Professional skills acquired

- Industry exposure
- Future scope

7. Chapter6–Conclusion
    - Summary of work
    - Achievements
    - Suggestions

References: IEEE format references

preferred Appendices

- Source codes nippets
- Certificates
- Additional screenshots

Savitribai Phule Pune University, Pune

Maharashtra, India

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Member, Board of Studies- Electronics & Telecomm Engineering

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PEC- 321- ETC (D) -Cloud Computing	
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PCC-352-ETC-Broad Band Communication	
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Dr Sarika Madhukar Jagtap	MVPS's KBTCOE Nashik

PEC-361 (A)-ETC Web Technology	
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Sachin B Pawar	Sinhgad college of Engg
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PEC-362- (B)-ETC Robotics and Automation Lab	
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PEC-362 (C) -ETC Artificial Intelligence	
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Dr. Vaishali Joshi	Trinity Academy of Engineering Pune
Dr. Pranoti Mane	MES's Wadia College of Engineering, Pune
Dr Rajashree Suryawanshi	Army Institute of Technology

PEC-362 (D) -ETC Industrial IoT	
Dr. Chandraprabha Manjare (Head)	Jayawantrao Sawant College of Engineering Hadapsar, Pune
Dr. Risi lChhatrala	International Institute of Information technology, pune

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