सावित्रीबाई फुले पुणे विद्यापीठ

Savitribai Phule Pune University, Pune, Maharashtra, India

Faculty of Science and Technology

National Education Policy (NEP)-2020 Compliant Curriculum

TE – Instrumentation and Control Engineering (2024 Pattern)

(With effect from Academic Year 2026-27)

www.unipune.ac.in

Nomenclature

AEC	Ability Enhancement Course
CCE	Comprehensive Continuous Evaluation
CEP	Community Engagement Project
CO	Course Outcomes
ESE	End-Semester Examination
MDM	Multidisciplinary Minor
OE	Open Elective
PCC	Program Core Course
VEC	Value Education Course
WK	Knowledge and Attitude Profile

Preface by Board of Studies

The rapid advancements in automation, intelligent systems, industrial communication, embedded technologies, and data-driven engineering have significantly transformed the domain of Instrumentation and Control Engineering. In alignment with these technological developments and the vision of the National Education Policy (NEP) 2020, the Board of Studies (BoS) in Instrumentation and Control Engineering has designed the Third Year Engineering (TE) curriculum with a strong emphasis on outcome-based education, multidisciplinary learning, industry relevance, innovation, and skill development.

The revised curriculum for TE Instrumentation and Control Engineering (2024 Pattern), implemented from the Academic Year 2026–27 under the Faculty of Science and Technology of Savitribai Phule Pune University, has been carefully structured to bridge the gap between academic learning and industrial expectations. The curriculum integrates core theoretical foundations with practical applications, experiential learning, vocational training, research orientation, and emerging technologies.

The curriculum includes contemporary subjects such as Embedded Systems, Industrial Automation, Modern Control Theory, Digital Signal Processing, Internet of Things, Virtual Instrumentation, Machine Learning, Artificial Intelligence, Robotics, Wireless Sensor Networks, and Building Automation. The inclusion of multidisciplinary minors, open electives, technical seminars, internships, and skill enhancement courses ensures holistic development of students and prepares them to meet the challenges of modern industries and research domains.

Special care has been taken to incorporate laboratory-intensive learning, project-based activities, and industry-oriented practices to enhance analytical, technical, and problem-solving abilities among students. The curriculum also promotes innovation, entrepreneurship, lifelong learning, ethical engineering practices, and sustainability.

The Board of Studies sincerely acknowledges the valuable contributions and suggestions received from academicians, industry experts, alumni, faculty members, and stakeholders during the curriculum design process. Their active participation has helped in developing a comprehensive and future-oriented curriculum aligned with national and global educational standards.

As the BoS Coordinator, I express my heartfelt gratitude to the Honorable Vice-Chancellor, Dean of Faculty of Science and Technology, all BoS members, subject experts, and contributors for their continuous support and guidance in the successful preparation of this curriculum structure and syllabus.

It is hoped that this curriculum will effectively nurture competent Instrumentation and Control Engineers equipped with technical expertise, professional ethics, leadership qualities, and innovative thinking to contribute meaningfully to society and industry.

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Department of Instrumentation & Control Engineering

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 areas 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.

Reference: Self-Assessment Report (SAR) Format Undergraduate Engineering Programs Graduate
Attributes and Professional Competencies Version 4.0 (GAPC V4.0) - (August 2024) Page 55.

Department of Instrumentation & Control Engineering

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. Instrumentation & Control, 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. (WK1 to WK4)

PO3: **Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

PO4: **Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: **Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

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).

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	12 Marks	Units 1 & Unit 2 (6 Marks/Unit)
2	Assignments / Case Study	12 Marks	Units 3 & Unit 4 (6 Marks/Unit)
3	Seminar Presentation / Open Book Test/ Quiz	06 Marks	Unit 5

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.	Parameter	Marks	Coverage of Units
1	Unit Test	10	Units 1 & Unit 2 (5 Marks/Unit)
2	Seminar Presentation / Open Book Test/ Assignments / Case Study	05	Units 3 & Unit 4

Format and Implementation of Comprehensive Continuous Evaluation (CCE)

- **Unit Test:**
  - **Format:** Questions designed as per Bloom's Taxonomy guidelines to assess various cognitive levels (Remember, Understand, Apply, Analyze, Evaluate, and 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** (2 Marks): Define key terms related to [Topic from Units 1 and 2].
  - **Understanding** (2 Marks): Explain the principle of [Concept] in [Context].
  - **Applying** (2 Marks): Demonstrate how [Concept] can be used in [Scenario].
  - **Analyzing** (3 Marks): Compare & contrast [Two related concepts] from Units 1 and 2.
  - **Evaluating** (3 Marks): 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 Units 3 and 4. Provide clear guidelines and a rubric for evaluation.

- **Seminar Presentation:**
  Seminar Presentation Format:
  - **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:**
  - Weeks 1-4 : Cover Units 1 and 2
  - Week 5 : Conduct Unit Test (12 marks)
  - Weeks 6-8 : Cover Units 3 and 4
  - Week 9 : Distribute and collect Assignments / Case Study (12 marks)
  - Weeks 10-12 : Cover Unit 5
  - Week 13 : Conduct Seminar Presentations or Open Book Test or Quiz (6 marks)

- **Evaluation and Feedback:**
  - **Unit Test:** Evaluate promptly and provide constructive feedback on strengths and areas for improve- ment.
  - **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.

By following this scheme, you can ensure a structured and comprehensive evaluation of students' understanding and application of the course material, adhering to Bloom's Taxonomy guidelines for cognitive skills evaluation.

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 of End-Semester Examination (ESE)

- 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 of facts 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 for 5-unit course and for 4-unit course 17 marks for two units and 18 marks for 2 units): 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 (8 marks for unit-1 and 9 marks for unit 2, 3 and 4.): 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.

Curriculum Structure - Semester V

Third Year Engineering (2024 Pattern)
TE -Instrumentation and Control 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	Theory	Tutorial	Practical	Total
Semester-V														
PCC-301-INC	Program Core Course 1	Embedded System	3	-	-	30	70	-	-	-	3	-	-	3
PCC-302-INC	Program Core Course 2	Industrial Automation-I	3	-	-	30	70	-	-	-	3	-	-	3
PCC-303-INC	Program Core Course 3	Modern Control Theory	3	-	-	30	70	-	-	-	3	-	-	3
PCC-304-INC	Program Core Lab Course 1	Embedded System Lab	-	-	2	-	-	-	50	-	-	-	1	1
PCC-305-INC	Program Core Lab Course 2	Industrial Automation-I Lab	-	-	4	-	-	-	50	-	-	-	2	2
PCC-306-INC	Program Core Lab Course 3	Modern Control Theory Lab	-	-	2	-	-	-	50	-	-	-	1	1
PEC-321-INC	Program Elective-I Course	Elective-I	3	-	-	30	70	-	-	-	3	-	-	3
PEC-322-INC	Program Elective-I Lab Course	Elective-I Lab	-	-	2	-	-	25	-	-	-	-	1	1
MDM-331-INC	Multidisciplinary Minor	Product Design and Manufacturing Lab	-	1	2	-	-	25	-	25	-	1	1	2
	Open Elective*	Open Elective*	2	-	-	15	35	-	-	-	2	-	-	2
ELC-342-INC	Experiential Learning Course (Research Methodology)	Technical Seminar	-	-	2	-	-	25	-	-	-	-	1	1
Total			14	1	14	135	315	75	150	25	14	1	7	22
			29Hrs			450 Marks		250 Marks			22 credits			

Course Code	Program Elective-I Course
PEC-321-INC-A	Analytical Instrumentation
PEC-321-INC-B	Bio Medical Instrumentation

*Note: Students can opt for Open Electives offered by different discipline/faculty like Arts, Science, Commerce and Management, Humanities or Inter-Disciplinary studies. Example - Statistics and Computer Applications, Business Administration

PEC-321-INC-C	Machine Learning

Curriculum Structure - Semester VI

Third Year Engineering (2024 Pattern)
TE -Instrumentation and Control Engineering

Level 6.0															
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	Theory	Tutorial	Practical	Total
Semester VI															
PCC-351-INC	Program Core Course 1	Industrial Automation-II	3	-	-	30	70	-	-	-	3	-	-	3
PCC-352-INC	Program Core Course 2	Digital Signal Processing	3	-	-	30	70	-	-	-	3	-	-	3
PCC-353-INC	Program Core Lab Course 1	Industrial Automation-II Lab	-	-	2	-	-	-	50	-	-	-	1	1
PCC-354-INC	Program Core Lab Course 2	Digital Signal Processing Lab	-	-	2	-	-	-	50	-	-	-	1	1
PEC-361-INC	Program Elective-II Course	Elective-II	3	-	-	30	70	-	-	-	3	-	-	3
PEC-362-INC	Program Elective-III Course	Elective-III	3	-	-	30	70	-	-		3	-	-	3
PEC-363-INC	Program Elective-III Course	Elective-III Lab	-	-	2	-	-	-	-	50	-	-	1	1
MDM-371-INC	Multidisciplinary Lab Minor	Internet of Things Lab	-	1	2	-	-	25	-	25	-	1	1	2
VSE-372-INC	Vocational and Skill Enhancement Course	Solar Technology and Maintenance	-	-	2	-	-	50	-	-	-	-	1	1
ELC-381-INC	Experiential Learning Course (Internship/OJT)	Internship	-	-	8	-	-	50	-	-	-	-	4	4
Total			**12**	**1**	**18**	**120**	**280**	**125**	**100**	**75**	**12**	**01**	**09**	**22**
			31 Hrs.			**400 Marks**		**300 Marks**			**22 Credits**			

Course Code	Program Elective Course-II
PEC-361-INC -A	Power Plant Instrumentation
PEC-361-INC-B	Robotics
PEC-361-INC-C	Wireless Sensor Network

Course Code	Program Elective Course-III
PEC-362-INC-A	Artificial Intelligence
PEC-362-INC-B	Power Devices and Control
PEC-362-INC-C	Building Automation

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Semester - V

TE – Instrumentation & Control Engineering (2024 Pattern)

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Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-301-INC **Course Name: Embedded Systems**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	CCE : 30 Marks End-Semester: 70 Marks

Prerequisite Courses, if any:

The students should be conversant with digital numbering system, digital electronics, digital logic design, Boolean expressions, sensors and basic programming concepts.

Course Outcomes:

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

1. Examine architectural details of 8051 microcontrollers, memory organization, addressing modes, Instruction set with programming model, software development cycle and assembler directives.
2. Analyze Timer/Counters, Interrupt, Stack operation and Serial Communication of 8051 microcontroller.
3. Design and develop interfacing of input and output devices with 8051 microcontroller using assembly level or C programs.
4. Design and develop an embedded system for Temperature On/Off Control, Speed Control of Induction Motor, Speed Control of D.C. Motor, Environmental parameter monitoring based on 8051microcontroller using assembly level or C programs.

Course Contents

Unit I	Introduction to Embedded System and 8051 Microcontroller	(08 Hours)

General purpose computer systems, history, classifications, applications, and purpose of embedded systems. Microprocessors and microcontrollers, RISC and CISC controllers, Blocks of 8051 Microcontroller, General purpose registers. Pin diagram of 8051 microcontrollers. Clock circuit, reset circuit, phase and state in machine cycle and timing diagram of 8051, I/O Ports structure.

Memory organization: Program and Data Memory Map, Internal RAM, Internal ROM. External Memory Addressing and Decoding Logic. Stack, Stack Pointer and Stack operation.

Addressing Modes: Immediate, Register, Direct, Indirect, Indexed, Relative and bit addressing.

Modes of operation: Power down and idle mode.

Unit II	Timers/Counters, Interrupt, Serial Communication	(08 Hours)

Timers & Counters: Timers/Counters logic diagram and its operation in various modes. Configuration of Timer/Counter using SFRs: TMOD, TCON.

Interrupt: Interrupt structure, vector address, priority and operation. ISR – Interrupt Service Routine. Configuration of interrupts using SFRs - IE, IP.

Serial Communication: Various modes, Configuration using SFRs - SCON, SBUFF, PCON.

Unit III	Instructions and Programming	(08 Hours)

Instruction set: Data Transfer, Arithmetic, Logical, Branching, Machine Control, Stack operations and Boolean operations. Looping, Counting, Sorting, Indexing, Data manipulation, Masking, Stack operation, Conditional programming.

Software development cycle: editor, assembler, cross-compiler, linker, compiler. Assembler Directives: ORG, DB, EQU, END, CODE, DATA. Programming: Time delay loop, Look-up table, Bit addressability.

Unit IV	External Device Interfacing with 8051 Microcontroller	(08 Hours)

Interfacing of Pushbutton, Matrix keypad, Limit Switches, Optical Sensors, 8 bit ADC, 8-bit DAC, LM35, RTD, Thermocouple, LDR, Relays, LEDs, &-Segment Display, LCD Display, DC and Stepper motor using ULN2003 and L298.

Unit V	Application Development	(08 Hours)

Develop an embedded applications including Block diagram, interface design, flowchart, and programming for Temperature ON/OFF controller, Speed Control of Induction Motor, Speed Control of D. C. Motor, Environmental parameter monitoring, Traffic Control System.

Learning Resources

Text Books:

1. The 8051 Microcontroller Architecture, Programming and Applications by Kenneth J. Ayala, Penram International Publications.
2. The 8051 Microcontroller and Embedded Systems – using assembly and C, Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; PHI, 2006 / Pearson, 2006.
3. “Microcontrollers: Architecture, Programming, Interfacing and System Design”, Raj Kamal, Pearson Education, 2005.
4. Embedded System Design – Frank Vahid, Tony Givargis, John Wiley.

Reference Books:

1. The 8051 Microcontroller Based Embedded Systems”, Manish K Patel, McGraw Hill, 2014, ISBN: 978-93-329-0125-4.
2. Programming and customizing the 8051 microcontroller, Predko Michael, McGraw-Hill, International edition.
3. Embedded Systems – Lyla, Pearson, 2013

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Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-302-INC **Course Name: Industrial Automation-I**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	CCE : 30 Marks End-Semester: 70 Marks

Prerequisite Courses: Students should have basic knowledge of electrical/electronic fundamentals, digital logic, and control systems.

Course Outcomes:

1. Interpret the fundamentals of industrial automation, PLC architecture, I/O systems, and programming standards as per IEC 61131-3.
2. Develop PLC ladder programs using basic and advanced instructions for industrial control applications.
3. Analyze and develop analog PLC programming, PID control, HMI, and VFD operations in industrial automation systems.
4. Develop SCADA-based automation systems incorporating data acquisition, monitoring, alarm management, and reporting features.

Course Contents

Unit I	Introduction to Automation and PLC	(07 Hours)

Fundamentals, need, role, types and evolution of industrial automation; PLC basics including definition, architecture, types and selection criteria; DI, DO, AI, AO signal processing, I/O interfacing, sinking and sourcing, program scan cycle, advantages and disadvantages; and introduction to PLC programming languages as per IEC 61131-3. Overview of major PLC manufacturers and comparison of specifications.

Unit II	Basic PLC Programming	(07 Hours)

PLC input and output instructions; Boolean algebra and logic gates, development of relay logic; ladder programming for Boolean equations, process control applications; Timer and counter instructions; and applications of timers and counters in industrial processes.

Unit III	Advanced PLC Programming	(10 Hours)

Comparison instructions: Equal, Not equal, Less than, Greater than, Less than or equal to, Greater than or equal to, Limit test, Masked compare equal to; Mathematical operations: ADD, SUB, MUL, DIV, SQR and NEG; Logical operations: AND, OR, NOR, EX-OR and NOT; Data

handling instructions: MOVE, Masked MOVE and CLEAR; Program control instructions: Jump & Label, Skip and Master Control Relay (MCR); Advanced instructions: Bit pattern in a register, shift register and sequencer; and applications using advanced PLC programming instructions.		
Unit IV	**Analog PLC Programming, HMI and Industrial Drive Systems**:	**(08 Hours)**
Analog PLC programming; PID control; Fundamentals of HMI, need, advantages; VFD: Working principle, construction, speed control methods, modes, applications; Motion control: Introduction, elements, block diagram and applications; PLC interfacing to HMI, VFD, hydraulic and pneumatic systems.		
Unit V	**Supervisory Control & Data Acquisition (SCADA)**	**(08 Hours)**
Definition, need, applications and benefits of SCADA; architecture and components; types of SCADA; PLC vs RTU; functions including data acquisition, supervisory control, trending, historical data, reporting and alarm management; Overview of SCADA software; and programming techniques such as page creation, sequencing, graphics, animation and basic application development.		

Learning Resources

Text Books:

1. Programmable Logic Controllers: Principles & Applications by John W. Webb, Ronald A. Reis, Prentice Hall of India, 5th ed.
2. Introduction to Programmable Logic Controllers by Gary Dunning, Delmar Thomson Learning, 3rd ed.
3. Programmable Logic Controllers: Programming methods and applications by John R. Hackworth and Frederick D. Hackworth Jr., Pearson publication

Reference Books:

1. Programmable Logic Controller by Frank D. Petruzella, McGraw-Hill Education, 5th ed.
2. Programmable Logic Controllers by W. Bolton, Elsevier Newnes publication, 4th ed.
3. Programmable Controller by T. A. Huges, ISA publication, 2nd edition.
4. SCADA by Stuart A. Boyer, ISA 1999.
5. HMI and SCADA: Theory and Practice – Stuart A. Boyer

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Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-303-INC **Course Name: Modern Control Theory**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	Practical : 50 Marks

Course Outcomes:

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

1. Analyze the dynamic behavior of linear systems using state space representation.
2. Design state feedback controllers and assess system stability using pole placement techniques.
3. Design state observers for accurate estimation of system states.
4. Model and analyze discrete-time systems by developing mathematical representations and realizing their structures.
5. Analyze the stability of continuous and discrete-time control systems using appropriate analytical methods.

Course Contents

Unit I	Introduction to State Space	(06 Hours)

Terminology of state space (state, state variables, state equations, state space and state model), state space representation, physical variable state space representation, phase variable forms (companion forms: controllable canonical form and observable canonical form). Canonical variable forms: diagonal canonical and Jordan canonical forms, determination of transfer function from state space Model.

Unit II	Analysis of control system in state space	(08 Hours)

Concept of eigen values and eigen vectors, diagonalisation of plant matrix through similarity transformations, Vander Monde matrix, solution of homogeneous state equation, state transition matrix: definition, derivation and properties, computation of state transition matrix by Laplace transform method, Cayley Hamilton method, similarity transformation method, solution of non-homogeneous state equation

Unit III	Design concepts in state space	(10 Hours)

Concept of controllability: definition, controllability matrix, concept of Observability: definition, Observability matrix. Investigation of state controllability and state Observability using Kalman's test, Gilbert's test, State variable feedback, control system design via pole placement: necessary and sufficiency condition, computation of state feedback gain matrix K through sufficiency condition, Ackermann formula and coefficient comparison method. State observer: necessity, types, theory, principle of duality between state feedback gain matrix K and observer gain matrix Ke, design of full order state observer.

Unit IV	Sampled data Control Systems	(08 Hours)

Introduction to discrete time control systems, necessary for digital control system, block diagram of digital control systems, operation and equivalents of ADC and DAC, analytical equivalent block diagram of digital control system, sampling and reconstruction process, sampling theorem, Operation and transfer function of zero order hold.

Unit V	Analysis of Sampled data Control Systems	(08 Hours)

Solution of difference equations using Z transforms method, pulse transfer function, stability analysis of discrete time control systems using Jury stability test, bilinear Transformation and Routh stability test.

Learning Resources

Text Books:

1. K. Ogata, "Modern Control Engineering", Fourth Edition, Prentice Hall of India, 2002.
2. M. Gopal, "Control Systems, Principles and Design", Second Edition, TMH, New Delhi, 2002.
3. A. Nagoor Kani, Control System, RBA Publications.
4. M. Gopal , Digital Control & State Variable Methods, TMH.

Reference Books:

1. B. C. Kuo, "Automatic Control Systems", Seventh Edition, Prentice Hall of India, New Delhi, 2002.
2. J. Nagrath and M. Gopal, "Control System Engineering", Second Edition, Wiley Eastern Limited.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-304-INC **Course Name: Embedded Systems Lab**

Teaching Scheme	Credit	Examination Scheme
Practical: 2 Hours/Week	**01**	**Practical: 50 Marks**

Prerequisite Courses, if any:

The students should be conversant with digital numbering system, digital electronics, digital logic design, Boolean expressions, sensors and basic programming concepts.

Course Outcomes:

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

1. Execute assembly language programs incorporating various addressing modes and assembler directives effectively.
2. Implement arithmetic and logical instructions to perform arithmetic and logical operations in embedded systems.
3. Use timers and interrupts to generate waveforms and interface with external devices using assembly or Embedded C language.

List of Experiments:

Students are expected to perform minimum eight experiments: (Any six from 1–9 and any two from 10–12)

1. Write and test Assembly Language program based on various addressing modes and assembler directives.
2. Write and test Assembly Language programs based on Arithmetic Instructions (8/16 bit Addition, Subtraction, Multiplication, Division).
3. Write and test Assembly Language programs based on Logical Instructions (AND, OR, Rotate, etc.).
4. Write and test Assembly Language programs based on Branch Instructions.
5. Write and test Assembly Language programs based on Looping, Counting, and Indexing concept.
6. Write and test Assembly Language programs to introduce delay (e.g.1ms Delay) using Timer/Counter.
7. Write and test Assembly Language programs to turn ON/OFF LED using interrupt.
8. Write and test Assembly or Embedded C Language programs to generate various

waveforms (square, triangular, sawtooth, trapezoidal) using timers.

9. Write and test Assembly or Embedded C Language programs to interface 4x4 matrix keypad.
10. Write and test Assembly or Embedded C Language programs to interface stepper motor and rotate in clockwise and anticlockwise direction.
11. Write and test Assembly or Embedded C Language programs for temperature display using LM35 temperature sensor by configuring ADC on LCD display.
12. Write and test Assembly or Embedded C Language programs to interface 16x2 LCD display.

Learning Resources

Text Books:

1. The 8051 Microcontroller Architecture, Programming and Applications by Kenneth J. Ayala, Penram International Publications.
2. The 8051 Microcontroller and Embedded Systems – using assembly and C, Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; PHI, 2006 / Pearson, 2006.
3. “Microcontrollers: Architecture, Programming, Interfacing and System Design”, Raj Kamal, Pearson Education, 2005.
4. Embedded System Design – Frank Vahid, Tony Givargis, John Wiley.

Reference Books:

1. The 8051 Microcontroller Based Embedded Systems”, Manish K Patel, McGraw Hill, 2014, ISBN: 978-93-329-0125-4.
2. Programming and customizing the 8051 microcontroller, Predko Michael, McGraw-Hill, International edition.
3. Embedded Systems – Lyla, Pearson, 2013

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-305-INC **Course Name: Industrial Automation-I Lab**

Teaching Scheme	Credit	Examination Scheme
Practical: 4 Hours/week	**02**	**Practical: 50 marks**

Prerequisite Courses: Students should have basic knowledge of electrical/electronic fundamentals, digital logic, and control systems.

Course Outcomes:

1. Implement simulations of ladder programs for diverse applications utilizing logic gates, timers, counters, and sequencers, and execute programs for alarm systems, batch mixers, and process control scenarios.
2. Differentiate and demonstrate knowledge of various PLC instructions by developing programs involving data movement, mathematical operations, and input/output functions for analog and BCD devices.
3. Organize and execute projects interfacing PLCs with external systems such as VFDs, motion control, hydraulic/pneumatic systems, HMI, and SCADA, showcasing integration skills for industrial automation applications.
4. Solve real-world problems by designing and developing PID controllers, SCADA systems, and motion control interfaces using PLCs, exhibiting proficiency in applying automation principles for advanced control systems.

List of Experiments: Students are expected to perform minimum 16 experiments.

1. Study of PLC Hardware, Architecture, and Programming Software of any Industrial PLC.
2. Development and Simulation of Ladder Program for simple on-off application.
3. Development and Simulation of Logic gates and Boolean equations.
4. Development and Simulation of Ladder Program using Timer Instructions.
5. Development and Simulation of Ladder Program using Counter Instructions.
6. Development and Simulation of Ladder Program for Cascading of Timer and Counter Instructions.
7. Development and Simulation of Ladder Program using Sequencer for Process Control Application.

8. Develop and Simulate Ladder program for Alarm Annunciator System.
9. Development and Simulation of Ladder program for Batch Mixer/any process application.
10. Development and Simulation of Ladder Program using Comparison and Logical Instructions.
11. Development and Simulation of Ladder Program using Data Movement and Program Flow Control Instructions.
12. Development and Simulation of Ladder Program using Mathematical and Special Mathematical Instructions.
13. Development and Simulation of Ladder Program for BCD Input/ Output and Analog Output Applications.
14. Development and Simulation of Ladder Program for Analog Input and Analog Output Applications.
15. Development and Simulation of PID Controller using PLC for Level/Flow/ Temperature/Pressure Control Systems etc.
16. PLC Interfacing with Hydraulic and Pneumatic Systems.
17. PLC Interfacing with Variable Frequency Drive (VFD) and its Control.
18. Interfacing Motion Control systems to PLC.
19. Design and Development of HMI for Start/Stop Control with PLC Tag Configuration.
20. Design and Development of SCADA System for Industrial Application.
21. SCADA Project Development including Graphics, Alarms, and Trend Configuration.

Learning Resources

Text Books:

1. Programmable Logic Controllers: Principles & Applications by John W. Webb, Ronald A. Reis, Prentice Hall of India, 5th ed.
2. Introduction to Programmable Logic Controllers by Gary Dunning, Delmar Thomson Learning, 3rd ed.
3. Programmable Logic Controllers: Programming methods and applications by John R. Hackworth and Frederick D. Hackworth Jr., Pearson publication

Reference Books:

1. Programmable Logic Controller by Frank D. Petruzella, McGraw-Hill Education, 5th ed.
2. Programmable Logic Controllers by W. Bolton, Elsevier Newnes publication, 4th ed.
3. Programmable Controller by T. A. Huges, ISA publication, 2nd edition.

4. SCADA by Stuart A. Boyer, ISA 1999.
5. HMI and SCADA: Theory and Practice – Stuart A. Boyer

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-306-INC **Course Name: Modern Control Theory Lab**

Teaching Scheme	Credit	Examination Scheme
Practical: 2 Hours/week	**01**	**Practical : 50 Marks**

Course Outcomes:

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

1. Execute the conversion of transfer function model to state space and vice-versa.
2. Implement the computation of state transition matrix using different methods.
3. Use techniques to investigate the state controllability of a given system.
4. Demonstrate the design of a state feedback controller through the pole placement approach

List of Experiments:

Students are expected to perform Minimum 8 Experiments.

1. Conversion of transfer function model to state space and vice-versa.
2. Computation of state transition matrix using different methods
3. Investigate state controllability of given system.
4. Investigate state Observability of a given system.
5. Design a state feedback controller through pole placement approach.
6. Design full order state observer using principle of duality.
7. Find the Response of the discrete time control system for standard inputs.
8. Determine effect of sampling period on stability of discrete time control system
9. Stability Analysis of Discrete Time Control System Using Jury's Method
10. Case Study on modern control system

Learning Resources

Text Books:

1. K. Ogata, "Modern Control Engineering", Fourth Edition, Prentice Hall of India, 2002.
2. M. Gopal, "Control Systems, Principles and Design", Second Edition, TMH, New
   a. Delhi, 2002.
3. A. Nagoor Kani, Control System, RBA Publications.
4. M. Gopal , Digital Control & State Variable Methods, TMH.

Reference Books:

1. B. C. Kuo, “Automatic Control Systems”, Seventh Edition, Prentice Hall of India, New
    a. Delhi, 2002.
2. J. Nagrath and M. Gopal, “Control System Engineering”, Second Edition, Wiley
    a. Eastern Limited.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-321-INC-A **Course Name: Analytical Instrumentation**

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

Prerequisite Courses, if any:

Course Outcomes:

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

1. Summarize the principles and mechanisms of membrane separation processes and radiation detection techniques.
2. Apply appropriate membrane separation and analytical techniques for specific industrial and environmental applications based on process requirements.
3. Analyse and compare different separation methods, mass spectrometry techniques, and radiation detectors based on efficiency, selectivity, and suitability.
4. Evaluate the performance, advantages, limitations, and safety aspects of advanced analytical instruments including mass spectrometers and nuclear radiation
5. Analyse and apply advanced analytical techniques in real-world industrial applications, considering their advantages, limitations, and safety aspects.

Course Contents

Unit I	**Introduction to Instrumental Methods of Chemical Analysis**	**(08 Hours)**

Introduction to Chemical Instrumental analysis, Advantages over Classical (wet) methods, Classification of Analytical Instruments, Units used in chemical analysis, Electromagnetic Spectrum, Light sources and detectors-Photomultipliers, Electron Capture Detector (ECD), Thermal Conductivity Detector (TCD), Flame Ionization Detector (FID).

Unit II	**Spectrometric Methods**	**(08 Hours)**

Laws of Photometry, UV and Visible Spectrophotometry, Single Beam and Double Beam instruments -Instrumentation (sources, detectors), Emission Spectrometry, Flame Emission Spectrophotometer, Atomic Absorption Spectrophotometer (AAS), Atomic Emission Spectrophotometer, Industrial and Scientific applications.

Unit III	**Chromatography Techniques**	**(08Hours)**

Liquid Chromatography (LC), High Performance Liquid Chromatography (HPLC), Types of columns, Detectors and Recorders, Applications of Chromatography

Unit IV	**Industrial Analyzers & Pollution Monitoring**	**(08 Hours)**

Flue gas analysis (thermal conductivity principle), Oxygen analyzers (paramagnetic principle, zirconia sensors), Pollution monitoring instruments - CO, NOx, H_2S analyzers, Turbidity analyzers, Industrial applications		
Unit V	**Advanced Analytical Techniques**	**(08 Hours)**
A. Separation Methods-Membrane Separation Processes-Microfiltration, ultrafiltration, Reverse osmosis, Dialysis and Electrodialysis, Applications **B. Mass Spectrometry (MS)-**Principle and Ionization Methods-Mass Analyzers -Magnetic Deflection, Time of Flight (TOF), Quadrupole, Double Focusing, Detectors and applications **C. Radioactive Instrumentation-**Nuclear radiation detectors -GM Counter ,Scintillation Counter ,Ionization Chamber ,Solid-State Detectors ,Gamma Spectrometry ,Industrial Applications		

Learning Resources

References:

1.Handbook of Analytical Instruments, R. S. Khandpur, Tata McGraw-Hill

1. Analytical Instrumentation by Bela G. Liptak, 1st edition, 1994

2. Introduction to Instrumental Analysis, Robert D. Braun, McGraw-Hill Book Company.

3. Principles of Instrumental Analysis, Skoog, Holler, Nieman, Saunders College Publishing, 1998

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-321-INC-B **Course Name: Biomedical Instrumentation**

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

Prerequisite Courses, if any:

Course Outcomes:

1. Articulate and characterize the origin of bio-potentials and inspect common biomedical signals by their characteristics features and analyze bio-potential.
2. Analyze the structure and functioning of the cardiovascular system and apply suitable biomedical instrumentation and signal processing techniques to measure and interpret cardiovascular parameters such as ECG, heart sounds, blood pressure, blood flow, and cardiac output.
3. Analyze neuro-muscular physiological signals using biomedical instruments such as EEG and EMG and interpret their significance in biomedical measurements.
4. Articulate anatomy and physiology of special senses and the natural breathing process of the respiratory system, determine problems related to it and specify the corrective action to be taken.
5. Operate ECG, EEG, PCG and BP, to monitor measure and analyze heart and brain activities.

Course Contents

Unit I	Bio-potential Measurement and Bio-transducers	(08 Hours)

Electrode-Electrolyte interface, half-cell potential, Polarization- polarizable and non-polarizable electrodes, Ag/AgCl electrodes, Electrode circuit model; motion artifact. Body Surface recording electrodes for ECG, EMG, and EEG. Internal electrodes- needle and wire electrodes. Micro electrodes- metal microelectrodes, Electrical properties of microelectrodes. Electrodes for electric stimulation of tissue.

Bio-transducers: Physiological parameters & suitable transducers for its measurements, operating principles & specifications for the transducers to measure parameters

Unit II	Cardiovascular System and Bio-signal Processing	(08 Hours)

Heart Structure, Cardiac Cycle, ECG Theory, ECG Electrodes, Electrocardiograph, Vector cardiograph Analog Signal Processing of Bio-signals, Amplifiers, Transient Protection, Interference Reduction, Movement Artifact Circuits, Active Filters, Rate Measurement, Averaging and Integrator Circuits, Transient Protection Circuits

Unit III	Cardiovascular Measurements	(08Hours)
Heart Sounds, Phonocardiography, Blood Pressure Measurement (Invasive and Non-invasive), Blood Flow meters: Magnetic, Ultrasonic, Thermal Convection Methods, Cardiac Output Measurement (dye dilution method), Plethysmography		
Unit IV	**Neuro-muscular System and Biomedical Measurements**	**(08 Hours)**
Brain & its parts, different waves from different parts of the brain, brain stem, cranium nerves, structure of neuron, Neuro muscular transmission, Electroencephalography, Evoked Response, EEG amplifier, Biofeedback Classification of muscles: Muscle contraction mechanism, Myoelectric voltages, Electromyography (EMG)		
Unit V	**Special Senses and Respiratory Instrumentation**	**(08 Hours)**
Ear: Mechanism of hearing and basic audiometry. **Eye:** Anatomy of the eye, visual acuity, and common errors of vision. **Respiratory Instrumentation:** Process of breathing, spirometers, airflow measurement, oxygenators (bubble and membrane type). Gas Analyzers: Infrared gas analyzer, Oxygen analyzer, Nitrogen analyzer, and Ventilators.		

Learning Resources

Text Books:

1. Vander, Sherman. Human Physiology- The Mechanism of Body Function TMH Ed.1981
2. Carr, Joseph J., and John Michael Brown. Introduction to biomedical equipment Technology. John Wiley & Sons, 1981.
3. Cromwell, Biomedical Instrumentation and Measurements 2nd edition, Pearson Education.
4. Khandpur, Raghbir Singh. Handbook of biomedical instrumentation. Tata McGraw-Hill, 1987.

Reference Books:

1. Tompkins, Willis J. Biomedical Digital Signal Processing. Vol. 237. New Jersey: Prentice Hall, 1993.
2. Arumugam, Biomedical Instrumentation
3. Ronald Pitts Crick, Pang Khaw, Text book of clinical Ophthalmology, 2nd Edition, World Scientific publication. ISBN 981-238-128-7.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-321-INC-C **Course Name: : Machine Learning**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	**03**	**CCE : 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any:

Data Structures, Data Science

Course Outcomes:

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

1. Summarize the fundamental concepts of Machine Learning and relate their significance to Instrumentation systems in areas such as data analysis, signal processing, and automation.
2. Perform data pre-processing, visualization, and analysis of sensor and industrial data.
3. Apply supervised learning algorithms for regression and classification problems in real-world applications & unsupervised learning techniques for pattern recognition and data clustering.
4. Analyze time-series data and understand basic neural network concepts for advanced applications.
5. Develop Machine Learning models for instrumentation applications such as fault detection, predictive maintenance, and process optimization.

Course Contents

Unit I	Introduction to Machine Learning	(07 Hours)

Basics of Machine Learning, Types: Supervised, Unsupervised, Reinforcement Learning, Applications in Instrumentation (process control, fault detection, predictive maintenance), Data types and datasets, ML workflow.

Unit II	Data Preprocessing & Visualization	(07 Hours)

Data collection from Sensors and Instruments, Data cleaning (missing values, noise filtering), Feature Scaling and Normalization, Data Visualization Techniques, Introduction to Python libraries: NumPy, Pandas, Matplotlib.

Unit III	Supervised & Unsupervised Learning Algorithms	(08Hours)

Supervised Learning Algorithm-Regression: Linear Regression, Polynomial Regression, Classification: k-NN, Decision Trees, Naïve Bayes, Model training and testing, Performance

metrics: Accuracy, Precision, Recall Unsupervised Learning Algorithm-Clustering: K-Means, Hierarchical Clustering, Dimensionality Reduction: PCA, Applications in Pattern Recognition and Signal Analysis		
Unit IV	**Advances in ML**	**(06 Hours)**
Introduction to Neural Networks, Basics of Deep Learning, Time-series analysis (important for sensor data), Introduction to IoT and ML integration		
Unit V	**Applications in Instrumentation**	**(07 Hours)**
Fault detection and diagnosis, Predictive maintenance of equipment, Process optimization Smart sensors and automation, Case studies from Industry		

Learning Resources

Text Books:

1. Machine Learning For Absolute Beginners by Oliver Theobald, Simon & Schuster India
2. Python Machine Learning by Sebastian Raschka and Vahid Mirjalili, Packt Publishing
3. Understanding Machine Learning by Shai Shalev-Shwartz and Shai Ben-David, Cambridge University Press.

Reference Books:

1. Introduction to Machine Learning with Python by Andreas C. Müller, Sarah Guido, O'Reilly Media, Inc.
2. Machine Learning for Dummies by John Paul Mueller and Luca Massaron, John Wiley & Sons, Inc.
3. Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies by John D. Kelleher, Brian Mac Namee, and Aoife D'Arcy, The MIT Press.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-322-INC-A Course Name: Analytical Instrumentation Lab

Teaching Scheme	Credit	Examination Scheme	
Practical:02 Hours/Week	**01**	**Term work:**	**25 marks**

Prerequisite Courses, if any:

Course Outcomes:

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

1. Implement different analytical techniques to analyse and evaluate samples effectively.
2. Interpret absorbance measurements using a Filter Photometer.
3. Analyse metal ion estimation using a Flame Photometer.

List of Experiments:

Students are expected to perform minimum eight experiments:

1. Analyse the construction and working of a Photomultiplier Tube (PMT).
2. Demonstrate the principle of a Filter Photometer for absorbance measurement.
3. Perform estimation of metal ions using a Flame Photometer.
4. Evaluate the working efficiency of a Reverse Osmosis (RO) system.
5. Determine sample concentration using a UV-Visible spectrophotometer.
6. Analyse air pollutant measurement using Air Quality Monitoring systems.
7. Operate a Gas Chromatograph (GC) for separation of mixture components.
8. Perform metal ion analysis using an Atomic Absorption Spectrophotometer (AAS).
9. Evaluate water quality using a Turbidity Analyser.
10. Describe and assess flue gas composition using a flue Gas Analyser.
11. Compare different chromatographic techniques for analytical applications.
12. Analyse the working of various detectors used in Analytical Instrumentation.

Learning Resources

References:

1.Handbook of Analytical Instruments, R. S. Khandpur, Tata McGraw-Hill

1. Analytical Instrumentation by Bela G. Liptak, 1st edition, 1994

2. Introduction to Instrumental Analysis, Robert D. Braun, McGraw-Hill Book Company.

3. Principles of Instrumental Analysis, Skoog, Holler, Nieman, Saunders College Publishing, 1998

Savitribai Phule Pune University Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern) Course Code: PEC-322-INC-B Course Name: Biomedical Instrumentation Lab		
Teaching Scheme	**Credit**	**Examination Scheme**
Practical:02 Hours/Week	**01**	**Term work: 25 marks**

Prerequisite Courses, if any:

Course Outcomes:

1. Execute bio-electrodes and preamplifiers in biomedical measurement applications accurately.
2. Use audiometry, Phonocardiogram, and photo plethysmography sensor to record and interpret biomedical signals proficiently.
3. Operate ECG, EEG, and BP, to monitor measure and analyze heart and brain activities.

List of Experiments:

Students are expected to perform minimum eight experiments:

1. To study bio-electrodes used in biomedical measurements and its applications.
2. To study various preamplifier used in biomedical applications.
3. To study and verify the specifications and operation of an Electrocardiograph (ECG) recorder.
4. To measure blood pressure using a sphygmomanometer and perform calibration of the BP apparatus.
5. To study the working principle and operation of an audiometer.
6. To study Phonocardiogram.
7. To record and monitor heart sounds using a stethoscope.
8. To study a photo plethysmography (PPG) sensor for pulse rate measurement.
9. To study the oxygenators.
10. To study the working principles of different types of blood flow meters.
11. To study blood flow meters.
12. To study the fundamentals and signal characteristics of Electroencephalography (EEG).
13. To study the fundamentals and signal characteristics of Electromyography (EMG).

Learning Resources

Text Books:

1. Vander, Sherman. Human Physiology- The Mechanism of Body Function TMH

Ed.1981

2. Carr, Joseph J., and John Michael Brown. Introduction to biomedical equipment Technology. John Wiley & Sons, 1981.
3. Cromwell, Biomedical Instrumentation and Measurements 2nd edition, Pearson Education.
4. Khandpur, Raghbir Singh. Handbook of biomedical instrumentation. Tata McGraw-Hill, 1987.

Reference Books:

1. Tompkins, Willis J. Biomedical Digital Signal Processing. Vol. 237. New Jersey: Prentice Hall, 1993.
2. Arumugam, Biomedical Instrumentation
3. Ronald Pitts Crick, Pang Khaw, Text book of clinical Ophthalmology, 2nd Edition, World Scientific publication. ISBN 981-238-128-7.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-322-INC-C **Course Name: : Machine Learning Lab**

Teaching Scheme	Credit	Examination Scheme
Practical: 2 Hours/week	**01**	**Term work: 25 marks**

Prerequisite Courses, if any:

Data Structures, Data Science

Course Outcomes:

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

1. Demonstrate proficiency in Python programming with NumPy and Pandas for data analysis.
2. Interpret and visualize sensor data using Matplotlib for analysis.
3. Use machine learning algorithms such as k-NN, Decision Trees, and Naïve Bayes for classification and clustering.
4. Demonstrate the ability to build predictive models for equipment maintenance using time-series analysis.

List of Experiments:

Students are expected to perform minimum 8 experiments.

1. Introduction to Python for Data Analysis
   a. Basics of NumPy and Pandas using sample sensor datasets
2. Sensor Data Acquisition & Visualization
   a. Import and visualize real/recorded instrument data using Matplotlib
3. Data Pre-processing of Instrumentation Data
   a. Handling missing values, noise filtering, normalization
4. Feature Extraction from Sensor Signals
   a. Extract statistical features (mean, variance, RMS, etc.)
5. Linear Regression for Calibration
   a. Apply regression to calibrate sensor output vs actual values
6. Polynomial Regression for Nonlinear Systems
   a. Model nonlinear behavior of instruments
7. Classification using k-NN Algorithm

a. Classify system states (normal vs faulty)

8. Decision Tree for Fault Diagnosis
    a. Identify faults in industrial processes
9. Naïve Bayes Classifier
    a. Apply probabilistic classification on instrument data
10. K-Means Clustering for Pattern Detection
    a. Group similar sensor readings or operating conditions
11. Time-Series Analysis of Sensor Data
    a. Analyze trends and predict future values
12. Case Study: Predictive Maintenance System
    a. Build a simple ML model to predict equipment failure

Learning Resources

Text Books:

1. Machine Learning For Absolute Beginners by Oliver Theobald, Simon & Schuster India
2. Python Machine Learning by Sebastian Raschka and Vahid Mirjalili, Packt Publishing
3. Understanding Machine Learning by Shai Shalev-Shwartz and Shai Ben-David, Cambridge University Press.

Reference Books:

1. Introduction to Machine Learning with Python by Andreas C. Müller, Sarah Guido, O'Reilly Media, Inc.
2. Machine Learning for Dummies by John Paul Mueller and Luca Massaron, John Wiley & Sons, Inc.
3. Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies by John D. Kelleher, Brian Mac Namee, and Aoife D'Arcy, The MIT Press.

Savitribai Phule Pune University Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern) Course Code: MDM-331-INC Course Name: Product Design and Manufacturing Lab		
Teaching Scheme	**Credit**	**Examination Scheme**
Tutorial: 01 Hours/Week **Practical: 02 Hours/Week**	**01** **01**	**TW :** **25 Marks**

Prerequisite Courses, if any:

Course Outcomes:

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

1. Analyze the phases of product design and development in instrumentation engineering.
2. Translate customer requirements into engineering specifications.
3. Design instrumentation-based products using systematic design tools.
4. Demonstrate prototypes for sensing, control, and monitoring applications.
5. Evaluate product performance, reliability, and manufacturability.
6. Prepare technical documentation and present product design solutions (with ergonomics and aesthetics).

Course Contents

Unit I	Introduction to Product Design and Development and Need Analysis	(08 Hours)

- Introduction to product design and development cycle
- Product life cycle and innovation stages
- Design thinking methodology
- Need identification and market analysis
- Voice of Customer (VOC)
- Customer need statement formulation
- Benchmarking and competitive analysis
- Product Design Specification (PDS)
- Quality Function Deployment (QFD)
- House of Quality
- Case studies of instrumentation products

Unit II	Concept Generation and Design Selection	(08 Hours)

- Brainstorming techniques
- Functional decomposition
- Morphological chart
- Concept generation methods
- Concept screening and scoring
- Weighted decision matrix
- Feasibility and risk analysis
- Ergonomics and industrial design aspects

Unit III	Detailed Design and Prototype Development	(08Hours)

- Sensor and transducer selection
- Signal conditioning design
- Controller selection (Arduino / ESP32 / PLC)
- PCB and interfacing basics
- Embedded product development
- Rapid prototyping concepts
- CAD-based hardware layout
- System integration

Unit IV	Testing, Validation, Reliability and Documentation	(08 Hours)

- Testing and validation techniques
- Calibration procedures
- Error analysis and performance evaluation
- Reliability and failure analysis
- FMEA
- Cost estimation and manufacturability
- Technical datasheet preparation
- User manual and lifecycle documentation

Based on above content list of some Practical Experiments / Assignments is as below.
Students are expected to perform minimum 08 Assignments/ Practical on above topics.

List of Experiments:

At least two practical from every unit should be conducted.

Unit wise practical list:

Unit I: Introduction to Product Design and Need Analysis

1. **Case Study Analysis of Instrumentation Product**
   Study an existing product (e.g., digital thermometer / pressure sensor) and map its design and development stages.
2. **Voice of Customer (VOC) Collection and Analysis**
   Conduct a survey for a selected product and convert customer feedback into structured needs.
3. **Customer Need Statement Formulation**
   Convert raw VOC data into clear engineering need statements.
4. **Benchmarking and Competitive Analysis**
   Compare similar instrumentation products and prepare a benchmarking chart.
5. **Preparation of Product Design Specification (PDS)**
   Develop a PDS document based on identified customer needs.
6. **Quality Function Deployment (QFD)**
   Construct a House of Quality matrix to relate customer needs to engineering characteristics.

Unit II: Concept Generation and Design Selection

1. **Brainstorming and Idea Generation Session**
   Generate multiple design concepts for a given problem statement.
2. **Functional Decomposition of Product**
   Break down a system into sub-functions and represent it using block diagrams.

3. **Morphological Chart Development**
   Create a morphological chart for alternative design solutions.
4. **Concept Screening using Pugh Matrix**
   Evaluate generated concepts using screening criteria.
5. **Weighted Decision Matrix for Concept Selection**
   Select the best concept using a scoring method.
6. **Feasibility and Risk Analysis**
   Analyze technical, economic, and operational feasibility of the selected concept.

Unit III: Detailed Design and Prototype Development

1. **Sensor and Transducer Selection Study**
   Select appropriate sensors for a given application with justification.
2. **Signal Conditioning Circuit Design**
   Design and simulate basic signal conditioning circuits (amplifier, filter).
3. **Microcontroller-Based System Development**
   Interface a sensor with Arduino/ESP32 and display data.
4. **Embedded System Prototype Development**
   Develop a basic monitoring/control system using sensors and controller.
5. **PCB Design Basics**
   Create a simple PCB layout using CAD tools.
6. **Rapid Prototyping and System Integration**
   Assemble and integrate hardware components into a working prototype.

Unit IV: Testing, Validation, Reliability and Documentation

1. **Calibration of Instrument/System**
   Perform calibration of a sensor or measurement system.
2. **Error Analysis and Performance Evaluation**
   Calculate accuracy, precision, and error of the developed system.
3. **Reliability Analysis and FMEA**
   Perform Failure Mode and Effects Analysis for the developed product.
4. **Testing and Validation of Prototype**
   Test the prototype under different conditions and validate performance.
5. **Cost Estimation and Manufacturability Study**
   Estimate production cost and analyze manufacturability aspects.
6. **Preparation of Technical Datasheet and User Manual**
   Develop complete documentation including specifications and usage guidelines.

Learning Resources

Reference Books:

1. Karl T. Ulrich & Steven D. Eppinger, *Product Design and Development*
2. Morris Asimow, *Introduction to Design*
3. Bela G. Liptak, *Instrumentation Engineers Handbook*
4. R. K. Jain, *Production Technology*

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: ELC-342-INC **Course Name: Technical Seminar**

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

Course Outcomes:

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

1. Identify and select emerging and relevant technical topics through literature survey.
2. Analyze and synthesize information from research papers, journals, and credible sources.
3. Demonstrate effective technical communication skills through oral presentation.
4. Prepare a structured technical report following academic writing standards.
5. 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 Computer Engineering.

Topic Selection Guidelines

- Topic must be from emerging Instrumentation and Control Engineering (last 3–5 years).
- Must involve a minimum of 5 recent research papers (IEEE, ACM, Elsevier, Springer etc). They should be summarizing paper – Reading abstracts and finding ideas, conclusion, Advantages of their approach, and the drawbacks of the papers. Generalize 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 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 approval by a faculty panel

Seminar Process

- **Stage 1: Orientation & Topic Finalization (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

- **Literature Survey & Problem Understanding (Week 2–4)**
  - Students must: Refer minimum 5–8 recent research papers (IEEE, Springer, Elsevier, ACM etc.)
  - Use scholarly databases like IEEE Xplore, Google Scholar, ScienceDirect
  - Prepare a literature survey matrix, including:
    - ❖ Author/year
    - ❖ Methodology used
    - ❖ Key findings
    - ❖ Limitations
  - Identify: Research gaps and Challenges in existing approaches
- **Synopsis Preparation & Presentation (Week 4–5)**
  - Submit a 2–3-page 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 hard copy (if required), Soft copy (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 skills

Method of Evaluation

- During the seminar session each student is expected to prepare and present a topic on engineering/technology, for duration of about 12 to 15 minutes.
- Each student is expected to present at least twice during the semester 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.

Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

Semester - VI

TE – Instrumentation & Control Engineering (2024 Pattern)

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Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-351-INC **Course Name: Industrial Automation-II**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	CCE : 30 Marks End-Semester: 70 Marks

Prerequisite Courses, if any: Basics of Industrial Automation.

Course Outcomes:

1. Apply the fundamentals of DCS in Industrial Automation.
2. Apply networking technologies such as RS232, RS485, OPC, HART, and Fieldbus protocols in DCS.
3. Analyse the software and hardware configuration of DCS.
4. Develop DCS programming for simple process applications.

Course Contents

Unit I	Introduction to Distributed Control System (DCS)	(07 Hours)

Distributed Control System (DCS): Introduction, need and evolution, role and location in process plants, functions and key features. DCS architecture: Overall system hierarchy, hardware and software components, Engineering Workstation (EWS), Operator Station (OS), controllers, I/O modules, communication networks, and system interfacing. Specifications, advantages and limitations of DCS. Comparison of DCS, PLC, and SCADA.

Unit II	DCS Networking & Communication	(09 Hours)

Concept of communication protocols and the OSI model. Communication standards:RS232 and RS485. Industrial communication protocols: Modbus (ASCII/RTU), HART, Foundation Fieldbus, Profibus, DeviceNet, ControlNet, and Industrial Ethernet. OPC and third-party interfaces for data exchange and system integration. Comparison of industrial communication protocols.

Unit III	DCS Configuration & Control	(08 Hours)

DCS structure, configuration, and redundancy concepts including system hierarchy and reliability aspects. Hardware configuration and system components used in DCS implementation. Concepts of process variables, software variables, tags, and database management in DCS. Basic controller configuration and parameter setting. Sequential controller configuration for batch process applications and controller configuration for continuous process control using function blocks and control strategies.

Unit IV	HMI, Alarm Management, Programming & Operation	(08 Hours)

Introduction to Human Machine Interface (HMI), design principles, features, and requirements. Plant mimic diagrams, animation, operator stations, loggers, recorders, trend displays, and data archiving. Alarm philosophy, prioritization, and management techniques. DCS programming based on IEC 61131-3 standards including Function Block Diagram (FBD) and Sequential Function Chart (SFC). DCS operation including operator roles, logs, reports, trends, system optimization, and use of mobile and remote interfaces.

Unit V	Advanced Control, IIoT Integration & Applications	(08 Hours)

Advanced control techniques: Fuzzy Logic, Artificial Neural Networks (ANN), Model Predictive Control (MPC). Overview: Integration of DCS with Industrial Internet and IIoT. Introduction to smart manufacturing and data-driven automation, predictive maintenance and remote monitoring and cybersecurity basics in industrial systems. Integration with enterprise systems (ERP). Any one industrial application of DCS.

Learning Resources

Text Books:

1. Krishna Kant, Computer-based Industrial Control, Prentice Hall, New Delhi, 1997.
2. Computer aided process control, S. K. Singh, PHI.
3. Distributed computer control for industrial automation, Popovik, Bhatkar, Dekkar Pub.
4. Understanding Distributed Process Systems for Control, Samuel Herb, ISA.

Reference Books:

1. B.G. Liptak, Process software and digital networks, CRC press, Florida.
2. Practical Distributed Control Systems for Engineers and Technicians-IDC technologies.
3. Programmable Logic Controllers – Frank D. Petruzella
4. Programmable Logic Controllers: Principles and Applications – John W. Webb & Ronald A. Reis
5. Introduction to Programmable Logic Controllers – Gary A. Dunning
6. HMI and SCADA: Theory and Practice – Stuart A. Boyer
7. The Internet of Things in the Industrial Sector: Security and Device Connectivity, Smart Environments, and Industry 4.0

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-352-INC **Course Name: Digital Signal Processing**

Teaching Scheme	Credit	Examination Scheme	
Theory: 3 Hours/Week	**03**	**CCE :**	**30 Marks**
		End-Semester:	**70 Marks**

Course Outcomes:

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

1. Analyze discrete-time LTI systems using convolution, difference equations, and z-domain techniques, transfer functions and pole-zero plots.
2. Apply frequency-domain analysis tools DTFS, DTFT, and DFT to analyze discrete-time signals. Implement efficient computation using FFT algorithms (DIT and DIF).
3. Design digital IIR filters based on analog prototypes Butterworth and Chebyshev filters. Implement transformation techniques including impulse invariance and bilinear transformation.
4. Design FIR filters with desired specifications using Fourier approximation, Windowing, and Frequency sampling.
5. Apply multirate signal processing techniques decimation, interpolation, and sampling rate conversion and implement decimators and interpolators.

Course Contents

Unit I	Introduction to Digital Signal Processing	(07 Hours)

Basic Block diagram of Digital Signal Processing, Basic Elements of Digital Signal Processing Applications of Digital Signal Processing. Sampling Theorem, Review of LTI discrete time systems: Linear Convolution and its properties, representation of LTI system using difference equation, solving difference equations and analysis of discrete-time systems in z-domain, Transfer Function, pole-zero plot. Correlation of Signals: Auto and Cross correlation.

Unit II	Frequency Domain Analysis	(09 Hours)

Ideal Frequency Selective Filters, Discrete-Time Fourier Series (DTFS), properties of DTFS, The Discrete Time Fourier Transform (DTFT), symmetry properties and theorems of DTFT, Discrete Fourier transform (DFT), properties of DFT, circular convolution, Efficient computation of DFT, Fast Fourier Transform (FFT) algorithms: Radix-2 Decimation- In-Time (DIT) and Decimation-In-Frequency (DIF)FFT algorithms.

Unit III	IIR filters	(08 Hours)

Introduction to analog IIR filters, Butterworth approximation, Chebyshev approximation. Design of digital IIR filter: impulse invariance method, bilinear transformation, approximation derivative method. Frequency transformations in analog and digital domain. Implementation of discrete-time systems: Infinite Impulse Response (IIR) structures for the realization.

Unit IV	FIR filters	(08 Hours)

Introduction to FIR filters, linear phase filters, symmetric and anti-symmetric filters, FIR design by Fourier approximation, window method, frequency sampling method, comparison between FIR and IIR filters. Implementation of discrete-time systems: Finite Impulse Response (FIR) structures for the realization.

Unit V	Multirate Digital Signal Processing	(08 Hours)

Multirate Digital Signal Processing: Introduction, Down sampling, Decimation, Up sampling, Interpolation, Sampling Rate Conversion, Implementation of Decimator and Interpolators, Applications of Multi Rate Signal Processing.

Learning Resources

Text Books:

1. A. Nagoor Kani, Digital Signal Processing, Tata McGraw Hill 2nd edition 2012.
2. P. Ramesh Babu, Digital Signal Processing, SciTech Publication, 7th edition, 2011.
3. Proakis, Manolakis, "DSP Principles, algorithms and applications-, Pearson, Fourth edition, 2009.

Reference Books:

1. Oppenheim and Schafer, "Discrete Time Signal Processing", Pearson Publication, 2nd edition, 2007
2. Ifeachor and Jervis, "Digital Signal Processing", Pearson Education India.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-353-INC **Course Name: Industrial Automation-II Lab**

Teaching Scheme	Credit	Examination Scheme
Practical: 2 Hours/week	01	Practical: 50 marks

Prerequisite Courses, if any: Basics of Industrial Automation.

Course Outcomes:

1. Understand the architecture, components, hardware/software configuration, and communication concepts of DCS systems.
2. Configure DCS communication networks and integrate field devices using industrial protocols.
3. Develop and simulate control logic using FBD, SFC, and PID function blocks in DCS.
4. Analyze industrial process applications and prepare DCS specifications for process automation systems.

List of Experiments:

Students are expected to perform minimum 8 experiments.

1. Study the basic architecture and components of a DCS system.
2. Create a new project and explore the DCS software environment.
3. Study hardware and software configuration in DCS.
4. Study communication protocols and the OSI model used in industrial automation.
5. Configure and test communication using RS232/RS485 and Modbus protocol.
6. Study and configure Profibus/HART/Foundation Fieldbus-based devices.
7. To start and stop electric motor/pump using DCS.
8. Configure field devices (transmitter and control valve) with DCS I/O channels.
9. Develop and simulate Function Block Diagram (FBD) programs for logic gate implementation.
10. Develop and simulate Sequential Function Chart (SFC) programs for timer applications.
11. Develop and implement a simple PID-based feedback control loop using function blocks.
12. Case study of DCS in an industrial application.
13. Prepare a specification sheet of DCS for a selected industrial application.

14. Industrial visit/field visit to any industrial automation industry.

Learning Resources

Text Books:

1. Krishna Kant, Computer-based Industrial Control, Prentice Hall, New Delhi, 1997.
2. Computer aided process control, S. K. Singh, PHI.
3. Distributed computer control for industrial automation, Popovik, Bhatkar, Dekkar Pub.
4. Understanding Distributed Process Systems for Control, Samuel Herb, ISA.

Reference Books:

1. B.G. Liptak, Process software and digital networks, CRC press, Florida.
2. Practical Distributed Control Systems for Engineers and Technicians-IDC technologies.
3. Programmable Logic Controllers – Frank D. Petruzella
4. Programmable Logic Controllers: Principles and Applications – John W. Webb & Ronald A. Reis
5. Introduction to Programmable Logic Controllers – Gary A. Dunning
6. HMI and SCADA: Theory and Practice – Stuart A. Boyer
7. The Internet of Things in the Industrial Sector: Security and Device Connectivity, Smart Environments, and Industry 4.0

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PCC-354-INC Course Name: Digital Signal Processing Lab

Teaching Scheme	Credit	Examination Scheme
Practical: 2 Hours/week	**01**	**Practical : 50 Marks**

Course Outcomes:

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

1. Generate discrete-time standard test signals as per given specifications and evaluate their characteristics through plots and analysis.
2. Interpret the results of linear convolution and understand its significance in signal processing applications.
3. Operate auto-correlation and cross-correlation functions to extract information about signal properties and relationships.
4. Solve filter design problems using windowing, Butterworth, and Chebyshev approximation methods, and evaluate the performance of the designed filters.

List of Experiments:

Students are expected to perform Minimum 8 Experiments.

1. Generate the discrete-time standard test signals viz. impulse, unit step, ramp, parabolic, exponential and sinusoidal signal.
2. Linear Convolution of the sequences.
3. Auto-correlation and Cross-correlations of the sequences.
4. DTFT of the sequence and Magnitude and Phase Spectrum
5. DFT of the given sequences.
6. Circular convolution of the given two sequences.
7. DFT using DIT FFT algorithm
8. DFT using DIF FFT algorithm.
9. Design and implement FIR filters using windowing method
10. Design and implement digital IIR filter using Butterworth approximations.
11. Design and implement digital IIR filter using Chebyshev approximations.
12. Implement and verify decimation and interpolation on a digital signal.

Learning Resources

Text Books:

1. Nagoor Kani, Digital Signal Processing, Tata McGraw Hill 2nd edition 2012.
2. P. Ramesh Babu, Digital Signal Processing, SciTech Publication, 7th edition, 2011.
3. Proakis, Manolakis, “DSP Principles, algorithms and applications-, Pearson, Fourth edition, 2009.

Reference Books:

1. Oppenheim and Schafer, “Discrete Time Signal Processing”, Pearson Publication, 2nd edition, 2007
2. Ifeachor and Jervis, “Digital Signal Processing”, Pearson Education India.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-361-INC-A Course Name: : Power Plant Instrumentation

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	CCE : 30 Marks End-Semester: 70 Marks

Prerequisite Courses, if any:

Sensors and Transducers, Control System Components.

Course Outcomes:

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

1. Analyze different power generation systems and their instrumentation.
2. Apply instrumentation and control techniques in conventional and renewable power plants.
3. Design basic automation and protection schemes for power plant operation.
4. Analyze SCADA, monitoring, and safety systems used in power plants.
5. Apply modern control and condition monitoring techniques for efficient energy management.

Course Contents

Unit I	Thermal Power Plant	(08 Hours)

Thermal power plant fundamentals including methods of power generation, plant layout, energy conversion processes, and material handling systems. Turbine and generator instrumentation focusing on control, speed, vibration monitoring, and operation of synchronous and induction generators.

Unit II	Nuclear Power Plant Instrumentation	(06 Hours)

Reactor core instrumentation including neutron flux measurement (source, intermediate, and power range), in-core/ex-core systems, and radiation detection methods for area and personnel monitoring. Safety & Protection Systems focusing on RPS, ECCS instrumentation.

Unit III	Hydraulic (Hydro) Power Plant Instrumentation	(08Hours)

Hydro power plant instrumentation including reservoir level measurement, spillway gate control, and flow measurement in penstocks. Turbine and generator systems such as governor control, speed/load regulation, blade pitch control, and electrical parameter monitoring with excitation and load sharing.Condition monitoring and automation focusing on vibration, temperature, SCADA-based control, remote operation, and protection against electrical faults.

Unit IV	Solar and Wind Power Plant Instrumentation	(09 Hours)

Study of solar energy systems includes solar resource assessment, PV and solar thermal technologies, system components, advantages, and safety considerations. Solar radiation measurement and PV instrumentation such as GHI/DNI monitoring, pyrometer and pyrheliometer usage, panel parameters, and MPPT-based power conversion. Study of Wind Energy system, Power in wind, Conversion of wind power, types of wind turbine, and modes of operation, wind mill, wind pumps, wind farms. Grid integration and automation focusing on synchronization, power quality, inverter monitoring and SCADA/IoT-based solar plant control and maintenance.

Unit V	Tidal and Geothermal Power Plant Instrumentation	(09 Hours)

Tidal energy systems including barrages and stream generators, with instrumentation for water level, flow measurement, turbine monitoring, and environmental parameters. Geothermal power plant instrumentation such as well/reservoir measurements, steam cycle monitoring, separator and turbine control, and corrosion/scaling detection. Automation and safety systems focusing on SCADA-based control, grid integration, emission monitoring, leak detection, and environmental protection.

Learning Resources

Reference Books:

1. Krishnaswamy, K., and Ponni Bala, M., Power Plant Instrumentation, 2nd Edition, PHI Learning, New Delhi, 2013, ISBN: 978-8120348240.
2. Liptak, B. G., Process Control: Instrument Engineers' Handbook, 4th Edition, CRC Press, Boca Raton, 2005, ISBN: 978-0849310812.
3. Rai, G. D., Non-Conventional Energy Sources, Revised Edition, Khanna Publishers, New Delhi, ISBN: 978-8174090737.
4. Nag, P. K., Power Plant Engineering, 4th Edition, McGraw Hill Education, New Delhi, 2014, ISBN: 978-1259005589.
5. Modern Instrumentation and Control for Nuclear Power Plants, International Atomic Energy Agency (IAEA), Vienna, 1999, Nuclear Energy Series Publication.
6. Basu, Swapan, and Debnath, Ajay Kumar, Power Plant Instrumentation and Control Handbook: A Guide to Thermal Power Plants, 1st Edition, Elsevier, 2009, ISBN: 978-0128009406.
7. Lindsley, David, Power-Plant Control and Instrumentation: The Control of Boilers and HRSG Systems, 1st Edition, Institution of Engineering and Technology (IET), London, 2000, ISBN: 978-0852967652.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC 361-INC-B **Course Name: Robotics**

Teaching Scheme	Credit	Examination Scheme
Tutorial: 3 Hours/Week	**03**	**CCE : 30 Marks** **End-Semester : 70 Marks**

Prerequisite Courses, if any:

Sensors & Transducers, Embedded System.

Course Outcomes:

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

1. Identify the components and classification of robots, explain Asimov's laws of robotics, and analyze the kinematics of robotic manipulators using the Denavit-Hartenberg representation.
2. Analyze and evaluate the dynamics and forces in robot systems, demonstrating an understanding of dynamic analysis and forces analysis.
3. Evaluate the use of grippers, sensors, and actuators in robotic systems, focusing on design considerations, force analysis, and applications.
4. Implement robot programming techniques, utilize various programming languages for robotic applications, and design automated assembly systems for specific tasks.

Course Contents

Unit I	Introduction to Robotics	(08 Hours)

Definition and history of robotics, Components of robot system, Classification of robots, Degrees of freedom, Asimov's laws of robotics, Robot anatomy (parts) and its working, DOF, Construction of links, Types of joints.

Classification of robots: Cartesian, Cylindrical, Spherical, SCARA, and Vertically Articulated Robots, Scope of robotics.

Unit II	Grippers, Sensors and Actuators	(08 Hours)

Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper systems.

Sensors for Robots: position, proximity, vision, temperature, force and torque sensors, applications of sensors in robotics.

Actuators: DC motors, AC motors, Stepper motors, and Servo motors.

Unit III	Robot Kinematics & Dynamics	(08 Hours)

Position Analysis forward and inverse kinematics of robots, including frame representations, transformations, position and orientation analysis, and the Denavit-Hartenberg representation of robot kinematics, the manipulators, the wrist motion. Kinematics of four-axis, five-axis, and six-axis robots.

Dynamic Analysis and Forces analysis of robot dynamics and forces.

Unit IV	Programming and Languages for Robotics	(08 Hours)

Robot Programming: Methods of robot programming, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc.

Unit V	Robots in Automatic Processing Operations, Assembly & Inspection	(08 Hours)

Introduction, spot welding, continuous arc welding, sprays coating, other processing operations. Assembly and robotic assembly automation, parts presentation methods, assembly operations, compliance and remote centre compliance (RCC) device, assembly system configurations, adaptable programmable assembly system, designing for robotic assembly, inspection automation.

Learning Resources

Text Books:

1. K. S. Fu, R. C. Gonzalez, C. S. G. Lee, Robotics Control, Sensing, Vision, and Intelligence, Tata McGraw Hill.
2. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education.
3. Mikell P. Groover, Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey and Ashish Dutta, “Industrial Robotics: Technology, Programming and Applications”, 2nd Edition, Tata McGraw Hill

Reference Books:

1. Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai.
2. Saeed B. Niku, – Introduction to Robotics: Analysis, Systems, Applications – Pearson Education Inc. New Delhi
3. Robert J. Schilling, Fundamentals of Robotics-Analysis and Control, Prentics Hall india.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-361-INC-C **Course Name: : Wireless Sensor Network**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	**CCE : 30 Marks** **End-Semester: 70 Marks**

Prerequisite Courses, if any: Basic knowledge of Data Communication Networks.

Course Outcomes:

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

1. Identify fundamental concepts of Wireless Sensor Networks (WSN), including architecture, node types, and system operation.
2. Examine and compare communication protocols in WSN based on performance metrics such as energy efficiency, scalability, and reliability.
3. Implement concepts of energy management, data handling techniques, and security mechanisms in Wireless Sensor Network environments.
4. Interpret middleware functions in Wireless Sensor Networks for resource coordination, data management, and application support.
5. Assess security challenges and advanced networking issues in WSN and recommend suitable solutions for mitigation.

Course Contents

Unit I	Introduction to Wireless Sensor Networks	(07 Hours)

Overview of Wireless Sensor Networks, Sensor node architecture (processor, memory, transceiver, power unit), Network architectures (flat, hierarchical, clustered), Applications in Industrial Instrumentation and monitoring, Design challenges (energy efficiency, scalability, fault tolerance).

Unit II	Communication Protocols & Standards	(08 Hours)

Physical and MAC layer issues in WSN, Energy-efficient MAC protocols (S-MAC, T-MAC), Routing protocols: Data-centric (Directed Diffusion), Hierarchical (LEACH), Location-based routing, Wireless communication standards: Zigbee protocol, Bluetooth Low Energy, Performance metrics: latency, throughput, reliability.

Unit III	Energy Management, Data Handling & Security	(08 Hours)

Energy consumption and power management techniques, Duty cycling and sleep scheduling, Data aggregation and data fusion, Time synchronization (TPSN, RBS),Localization methods, Security in WSN: Encryption, authentication, Secure routing mechanisms

Unit IV	Middleware for Wireless Sensor Networks	(05 Hours)

WSN Middleware Principles, Middleware Architecture, Existing Middleware-MiLAN, (Middleware Linking Applications and Networks), IrisNet (Internet-Scale Resource Intensive, Sensor Networks Services).

Unit V	Sensor Network Security- Network Security	(07 Hours)
Security in Ad Hoc Wireless Networks - Network Security Requirements. Network Security requirements issues and Challenges in security provisioning Network, Security Attacks, Layer wise attack in wireless sensor networks, possible solutions for Jamming, tampering black hole attack, Flooding attack, Key distribution and Management, Secure Routing –SPINS, Reliability requirements in sensors Networks, Sensor Network Platforms and Tool		

Learning Resources

Text Books:

1. Kazem Sohraby, Daniel Minoli, Taieb Znati, Wireless Sensor Networks: Technology, Protocols, and Applications, John Wiley and Sons.
2. Erdal Çayırcı, Chunming Rong, “Security in Wireless Ad Hoc and Sensor Networks, John Wiley and Sons, 2009.

Reference Books:

1. Holger Karl, Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley.
2. Ananthram Swami, Qing Zhao, Yao-Win Hong, Lang Tong, Wireless Sensor Networks, Signal Processing and Communications Perspectives, John Wiley.
3. C. S. Raghavendra, Krishna M. Sivalingam, Taieb Znati, Wireless Sensor Networks, Kluwer Academic.
4. Bhaskar Krishnamachari, Networking Wireless Sensors, Cambridge University Press

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-362-INC-A **Course Name: Artificial Intelligence**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	CCE : 30 Marks End-Semester: 70 Marks

Prerequisite Courses, if any:

Machine learning basics, Statistics for data science

Course Outcomes:

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

1. Understand the fundamental concepts of Artificial Intelligence and its role in computer-based instrumentation systems.
2. Apply search techniques and problem-solving methods to solve basic engineering problems in Instrumentation systems.
3. Develop and interpret knowledge-based systems using rule-based representation and inference mechanisms.
4. Analyze fuzzy logic and intelligent reasoning techniques for industrial control applications.
4. Evaluate AI applications Instrumentation engineering such as expert systems, SCADA, fault diagnosis, and Industrial Automation.

Course Contents

Unit I	Introduction to AI and Computer-Based Systems	(08 Hours)

Definition and scope of Artificial Intelligence, Evolution of AI systems, Types of AI (narrow AI, general AI – conceptual), Role of computers in AI implementation, AI in Instrumentation Engineering

Overview of intelligent computer-based control systems, Applications in Industrial Automation

Unit II	Problem Solving and Search Techniques	(08 Hours)

Problem formulation in AI, State space representation, Search strategies: Uninformed search (BFS, DFS concept), Informed search (heuristic search, A*), Heuristic functions (basic idea), Applications in Instrumentation and process optimization

Unit III	Knowledge Representation Techniques	(08Hours)

Logic-based representation-Rule-based systems, Frames and Semantic Networks, Expert systems Architecture, Inference Engine (forward & backward chaining), Applications in Fault Diagnosis and instrumentation, Applications in Pattern Recognition and Signal Analysis

Unit IV	Intelligent Systems and Reasoning	(08 Hours)
Symbolic reasoning, Uncertainty in AI (basic introduction), Fuzzy logic systems (conceptual overview), Decision-making systems in instrumentation, Computer-based intelligent control systems, AI-based monitoring systems		
Unit V	**AI Applications in Instrumentation Engineering**	**(08 Hours)**
Computer-based process control systems, SCADA and AI integration, Fault detection and diagnostics, systems, Industrial Automation using AI, Robotics in Instrumentation systems, Smart manufacturing and Industry 4.0 overview, Case studies in process industries.		

Learning Resources

Reference Books:

1. Stuart Russell, S., & Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson Education.
2. Patrick Henry Winston, P. H. Artificial Intelligence, Addison-Wesley.
3. I. Gupta, I., & G. Nagpal, G. Artificial Intelligence and Expert Systems, Khanna Publishing House.
4. C. S. Krishnamoorthy, C. S., & S. Rajeev, S.Artificial Intelligence and Expert Systems for Engineers. CRC Press (Taylor & Francis Group).
5. Peter Jackson, P. Knowledge-Based Systems in Artificial Intelligence. McGraw-Hill.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-362-INC-B **Course Name: Power Devices and Control**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	CCE : 30 Marks End-Semester: 70 Marks

Prerequisite Courses, if any:

The students should be conversant with semiconductor devices, AC and DC motors.

Course Outcomes:

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

1. Apply knowledge of physics of semiconductor and electronic devices to develop Describe, analyze characteristics and compare various types of power semiconductor devices to control power electronic systems.
2. Interpret the working principles of AC- DC, DC-DC, AC-AC and DC-AC converters.
3. Analyze and evaluate the performance of AC- DC, DC-DC, AC-AC and DC-AC converters in all the modes of operation.
4. Identify and design different power converters for specific applications.

Course Contents

Unit I	Power Semi-Conductor Devices	(07 Hours)

Silicon Controlled Rectifiers (SCR's), Two transistor analogy, Static and Dynamic characteristics, turn on and turn off methods, UJT firing circuit, Series and parallel connections of SCR's, Snubber circuit, Line Commutation and Forced Commutation circuits, Power MOSFET, Power IGBT, their characteristics.

Unit II	AC - DC Converters (1-Phase & 3-Phase Controlled Rectifiers)	(08 Hours)

Phase control technique, Single phase Line commutated converters, Half controlled converters with R, RL and RLE loads, Semi and Fully controlled converters, Bridge connections with R, RL, Three phase converters, Three pulse and six pulse converters, Dual converters (both single phase and three phase).

Unit III	DC - AC Converters and DC - DC Converters (Choppers)	(08 Hours)

Inverters – Single phase inverter, Basic series inverter, operation and waveforms, three phase inverters (120, 180 degrees' conduction modes of operation), Voltage control techniques for inverters, Pulse width modulation Techniques.

Choppers- Time ratio control and Current limit control strategies, Step down choppers, Derivation of load voltage and currents with R, RL loads, Step up Chopper.

Unit IV	AC - AC Converters	(08 Hours)

AC voltage controllers – Single phase two SCR's in anti-parallel with R and RL loads, modes of operation, Derivation of RMS load voltage, current and power factor wave forms. Cyclo converter types- R and RL loads (Principle of operation only), Bridge configuration of single phase cyclo converter (Principle of operation only). Variable frequency drives.

Unit V	Industrial Drives	(08 Hours)

Controllers for AC motors: Solid state relays, firing angle control, closed loop control of induction motor, Speed and direction control, AC Synchronous motor drive, Closed loop control of synchronous motor, Variable frequency drive. Regenerative braking.

Controllers for DC motors: H-Bridge Drive, Stepper motor sequencer and drive, Half step and Full step method of stepper motor drive, Chopper drive, Speed and direction control, Brushless DC Motor control drive.

Learning Resources

Text Books:

1. Rashid, M. H., "Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.
2. Bimal K Bose, " Modern Power Electronics and AC Drives" PHI
3. MD Singh, K B Khubchandani, 'Power Electronics', 2ndedition, McGraw Hill Company.

Reference Books:

1. Dubey .G.K. "Power semiconductor-controlled Drives", Prentice Hall international, New Jersey, 1989.
2. Fundamentals of Electric Drives By G K Dubey, Narosa Publications
3. P. C. Sen,' Power Electronics', TMH, 2007

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC362-INC-C **Course Name: Building Automation**

Teaching Scheme	Credit	Examination Scheme
Theory: 3 Hours/Week	03	CCE : 30 Marks End-Semester: 70 Marks

Prerequisite Courses, if any:

Fundamentals of Thermodynamics, Basics of Sensors and Transducers

Course Outcomes:

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

1. Analyze the architecture and communication protocols of BAS systems.
2. Apply sensing and measurement techniques for human comfort parameters.
3. Analyze HVAC, AHU, and VAV system operations in intelligent buildings.
4. Design basic fire alarm, access control, and CCTV system architectures.
5. Apply automation and security concepts for smart building management.

Course Contents

Unit I	Introduction to BAS System	(09 Hours)

Fundamentals of Building Automation Systems (BAS) and the evolution of intelligent buildings. Integration of BAS in planning, design, operation, and maintenance. Role and importance of HVAC, security, fire safety, and lighting systems. Communication protocols and addressing concepts. Open protocols (BACnet, LON, Profibus, Modbus, and M-bus) and proprietary protocols (N2, CBUS).

Unit II	Comfort parameters and measurement	(08 Hours)

Human comfort variables including temperature, humidity, pressure, and CO2 levels. Heat transfer (conduction, convection, radiation) and psychometric concepts (enthalpy, entropy, dew point). Characteristics of RTDs, thermistors, thermocouples, and bimetallic strips. Air/water side flow and pressure measurement; air filtration and UV/ozonisation techniques.

Unit III	HVAC Air Systems (AHU & VAV)	(08 Hours)

Introduction to air handling units (AHU): Design and operation of dampers, filters, coils, and heat recovery wheels. AHU Types: Constant volume, variable volume, dual duct, and single duct systems. Design of CAV and VAV units, including series/parallel fan-powered and reheat configurations. Principles of the refrigeration cycle.

Unit IV	Fire Alarm System & Fire Detection	(07 Hours)

Fire alarm System-The History, FAS architecture & operation Classification of Fire Alarm System, Conventional and Addressable Fire Alarm System Important Codes-NFPA72, IS 2189, BS 5839,FAS Loops-Classification of Loops and Examples, Power Supply Requirement and its designing parameters, Battery Calculations and Its Requirement and design Network terminology for Fire Systems, Classification of Cables, Class of Cables-Types and distance Supported specific to fire alarm system, SLC wiring and its classification.

Unit V	Building Security – Access Control & CCTV	(07 Hours)

Basic Concepts of Access Control System & it's components, Benefits of Access Control System & it's architecture, Access Control System Devices–Its features and Working principles. Card Technology Overview –Smartcard, Proximity Card, MI fare Cards, System Architecture of Access Control System, Basic of CCTV system, System Architecture of CCTV System, Types of Camera Video Analytics, Camera Connectivity, Video Management System.

Learning Resources

Text Books:

1. Haines, Roger W., HVAC Systems Design Handbook, 5th Edition, McGraw Hill Education, New York, 2006, ISBN: 978-0071486514.
2. Brumbaugh, James E., HVAC Fundamentals, Volumes 1–3, Industrial Press, New York, Latest Revised Editions Available, ISBN: 978-0831133474.
3. Indian Society of Heating, Refrigerating and Air Conditioning Engineers, Basics of Air Conditioning, Product Code: B0004, ISHRAE, New Delhi, India.

Reference Books:

1. Indian Society of Heating, Refrigerating and Air Conditioning Engineers, Chillers Basics, Product Code: B0009, ISHRAE, New Delhi, India.
2. Indian Society of Heating, Refrigerating and Air Conditioning Engineers, HVAC Handbook Part-1, ISHRAE, New Delhi, India, Latest Edition Available.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-363-INC-A **Course Name: Artificial Intelligence Lab**

Teaching Scheme	Credit	Examination Scheme
Practical:2 Hours/Week	01	Oral: 50 Marks

Prerequisite Courses, if any:

Machine learning basics, Statistics for data science

Course Outcomes:

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

1. Implement foundational AI concepts and tools by leveraging Python for problem-solving.
2. Use intelligent computer-based control systems for industrial automation applications.
3. Demonstrate proficiency in various search algorithms for problem-solving in AI.
4. Execute the development and simulation of AI-based systems in various real-world applications.

List of Experiments:

Students are expected to perform minimum eight experiments.

1. Study of Artificial Intelligence concepts, evolution of AI systems, and types of AI Basics of NumPy and Pandas using sample sensor datasets.
2. Installation and familiarization of AI tools using Python, Jupyter Notebook, or Google Colab.
3. Study of intelligent computer-based control systems and AI applications in Industrial Automation.
4. Implementation of Breadth First Search (BFS) algorithm for problem solving.
5. Implementation of Depth First Search (DFS) algorithm for state space search problems.
6. Implementation of heuristic search techniques and A* algorithm.
7. Representation of knowledge using Rule-Based Systems and Semantic Networks.
8. Implementation of Forward Chaining and Backward Chaining inference.
9. Development of a simple Expert System for fault diagnosis in Instrumentation systems.
10. Design and simulation of a Fuzzy Logic Controller for process control applications.
11. Simulation of AI-based intelligent monitoring and decision-making systems.
12. Study and demonstration of AI applications in SCADA, Robotics, Smart Manufacturing,

and Industry 4.0 systems.

Learning Resources

Reference Books:

1. Stuart Russell, S., & Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson Education.
2. Patrick Henry Winston, P. H. Artificial Intelligence, Addison-Wesley.
3. I. Gupta, I., & G. Nagpal, G. Artificial Intelligence and Expert Systems, Khanna Publishing House.
4. C. S. Krishnamoorthy, C. S., & S. Rajeev, S.Artificial Intelligence and Expert Systems for Engineers. CRC Press (Taylor & Francis Group).
5. Peter Jackson, P. Knowledge-Based Systems in Artificial Intelligence. McGraw-Hill.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC-363-INC-B **Course Name: Power Devices and Control Lab**

Teaching Scheme	Credit	Examination Scheme
Practical: 2 Hours/Week	01	Oral: 50 Marks

Prerequisite Courses, if any:

The students should be conversant with semiconductor devices, AC and DC motors.

Course Outcomes:

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

1. Implement the design and implementation of SCR triggering circuits.
2. Implement proper functioning of UJT triggering circuits for SCR.
3. Demonstrate efficiency in analyzing the performance of rectifiers under different load conditions.
4. Use appropriate speed control methods for different types of motors utilizing choppers and other control strategies.

List of Experiments:

Students are expected to perform minimum eight experiments.

1. Study of V–I characteristics of SCR and triggering circuits
2. Design and test UJT triggering circuit for SCR.
3. Performance of half wave uncontrolled rectifiers with various load.
4. Performance of full wave uncontrolled rectifiers with various load.
5. Performance of half wave controlled rectifiers with various load.
6. Performance of full wave controlled rectifiers with various load.
7. Single AC voltage controller using SCRs for R load.
8. Speed control of DC motor using choppers.
9. Study of DC motor speed control using chopper
10. Study of speed control of DC motor using H-bridge
11. Speed control of stepper motor with full step and half step sequence.
12. Pulse width modulation (PWM) control for servo, BLDC motor and miniature DC motor with direction control.

Learning Resources

Text Books:

1. Rashid, M. H., "Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.
2. Bimal K Bose, " Modern Power Electronics and AC Drives" PHI

3. MD Singh, K B Khubchandani, 'Power Electronics', 2ndedition, McGraw Hill Company.

Reference Books:

1. Dubey .G.K. "Power semiconductor-controlled Drives", Prentice Hall international, New Jersey, 1989.

2. Fundamentals of Electric Drives By G K Dubey, Narosa Publications

3. P. C. Sen,' Power Electronics', TMH, 2007

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: PEC363-INC-C Course Name: Building Automation Lab

Teaching Scheme	Credit	Examination Scheme
Practical: 2 Hours/week	**01**	**Oral: 50 marks**

Prerequisite Courses, if any:

Fundamentals of Thermodynamics, Basics of Sensors and Transducers

Course Outcomes:

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

1. Demonstrate the ability to interpret the architecture of Building Management Systems.
2. Implement the use of psychometric charts to analyze and adjust HVAC systems for optimal performance.
3. Differentiate between various types of Air Handling Units and **operate** them effectively in different building environments.
4. Analyze and solve problems related to terminal unit systems like CAV and VAV through practical applications.

List of Experiments:

Students are expected to perform minimum 8 experiments out of which one experiment should be based on signal conditioning.

1. To study Architecture of BMS
2. To study Psychometric chart and various parameters
3. To study different types of Air Handling Units
4. To study various terminal unit systems (CAV, VAV)
5. To study Chilled Water System and loops
6. To study Hot Water System and loops
7. To study FAS loops and classifications
8. To study SLC wiring, loops, classifications
9. Development and study of a Cause and Effect matrix for Fire Alarm Systems.
10. To study of CCTV System architecture and the various types of surveillance cameras.

Learning Resources

Text Books:

1. Haines, Roger W., HVAC Systems Design Handbook, 5th Edition, McGraw Hill

Education, New York, 2006, ISBN: 978-0071486514.

2. Brumbaugh, James E., HVAC Fundamentals, Volumes 1–3, Industrial Press, New York, Latest Revised Editions Available, ISBN: 978-0831133474.
3. Indian Society of Heating, Refrigerating and Air Conditioning Engineers, Basics of Air Conditioning, Product Code: B0004, ISHRAE, New Delhi, India.

Reference Books:

1. Indian Society of Heating, Refrigerating and Air Conditioning Engineers, Chillers Basics, Product Code: B0009, ISHRAE, New Delhi, India.
2. Indian Society of Heating, Refrigerating and Air Conditioning Engineers, HVAC Handbook Part-1, ISHRAE, New Delhi, India, Latest Edition Available.

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: MDM-371-INC **Course Name: Internet of Things Lab**

Teaching Scheme	Credit	Examination Scheme
Tutorial: 1 Hours/Week	**01**	**Term Work: 25 marks**
Practical: 2 Hours/week	**01**	**Oral : 25 Marks**

Prerequisite Courses, if any:

Sensors & Transducers, Digital Electronics, Fundamentals of programming, Embedded System

Course Outcomes:

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

1. Apply the fundamental concepts, characteristics, and components of IoT systems to design basic IoT-based applications.
2. Identify and describe the IoT enabling technologies, communication models, and internet protocols such as MQTT and IEEE 802.15.4.
3. Implement cloud computing architecture for IoT applications and compare cloud deployment and service models.
4. Analyze IoT security threats, propose countermeasures for cloud security, and evaluate the applications of IoT.

Course Contents

Unit I	Introduction to Internet of Things	(04 Hours)

IoT Basics: Definition, Characteristics, components of IoT system, challenges and opportunities in IoT implementation, IoT Hardware Platforms: Arduino, Node MCU, Raspberry Pi, Routers and Switches, IoT Programming: Arduino IDE, Python for Raspberry Pi.

Unit II	IoT Enabling Technologies and Communication Protocols	(04 Hours)

Inspection: OSI Model (simple overview), IoT Enabling Technologies, IoT communication Models, Internet Protocol: 6LoWPAN, MQTT, Wireless HART, IEEE 802.15.4

Unit III	Cloud computing for IoT	(04 Hours)

Cloud computing for IoT: Architecture, General and Essential characteristics, cloud deployment and service models.

Fog computing: Introduction, requirements, advantages and challenges.

Unit IV	IoT Security and Applications	(03 Hours)

IoT Threats and Attacks, cloud security, Home automation, Smart cities, Transportation and

Logistics

List of Experiments:

Students are expected to perform minimum 8 experiments:

1. Interfacing of digital sensor/switch with developing board and display of condition on LED and on LCD
2. Interfacing analogue temperature sensor with developing board and displaying its value on LCD.
3. Interfacing of development boards with python.
4. Communication of smartphone to development board using Bluetooth.
5. Connecting development board to internet either with Wi-Fi.
6. Sending information to cloud using development board.
7. Receiving data from cloud to development board and displaying it on LCD.
8. Interfacing of DC motor to development board using motor driver.
9. Temperature ON/OFF control of load using development board.
10. Design of Traffic Light Simulator using development board.
11. Design of Motion Sensor Alarm using PIR Sensor.
12. Interfacing of Alarm System with Raspberry Pi.

Learning Resources

Text Books:

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach",Universities Press, 2015.
2. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by CRC Press.
3. Jeeva Jose, Internet of Things, Khanna Publisher, Edition: First, ISBN: 9789386173591

Reference Books:

1. E Hakima Chaouchi, "The Internet of Things Connecting Objects to the Web", ISBN: 978-1-84821-140-7, Willy Publications.
2. Dieter Uckelmann, Mark Harrison, Florian Michahelles, Architecting the Internet of Things, Springer, ISBN 978-3-642-19156-5
3. Pascal Ackerman, "Industrial Cybersecurity: Efficiently Secure Critical Infrastructure Systems", Packet Publication, 2017

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: VSE-372-INC Course Name: Solar Technology and Maintenance

Teaching Scheme	Credit	Examination Scheme	
Practical: 2 Hours/week	**01**	**Term Work:**	**50 marks**

Prerequisite Courses, if any:

Basic knowledge of Physics (especially topics like electricity, magnetism semiconductors, light/energy concepts, Basic Electrical Engineering or Basic Electronics, Engineering Mechanics. Heat and energy concepts

Course Outcomes:

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

1. Apply safe installation, wiring, commissioning, and performance measurement of basic solar PV systems.
2. Analyze the impact of environmental/operational factors on solar PV efficiency and diagnose common faults.
3. Evaluate the effectiveness of maintenance and troubleshooting procedures for solar PV components and systems.
4. Create simple practical solutions or documentation for improving solar system performance via mini-projects.

Practical Assignments

Experiment no.1, 2 and 10 are compulsory.
Perform any 2 Experiments from 3 to 5 and
Perform any 3 Experiments from 6 to 9

1. Measurement of solar irradiance using pyrometer/lux meter at different times/angles. Real-
   World Assignment: Survey irradiance on your college rooftop for one day. Calculate daily energy generation for a 100W panel and suggest best installation time/angle for maximum output.
2. Plot I-V and P-V characteristics of solar PV module under varying light & temperature. Real-World
   Assignment: Simulate cloudy/rainy day conditions. Calculate module efficiency and

estimate annual energy loss in Pune climate.

3. Survey and Comparative Analysis of Solar PV Installation Systems: Grid-Tied, Hybrid, and Off-Grid Configurations.

   Real-World Assignment: Survey 2–3 real solar installations (e.g., college rooftop, nearby home/business, or online/virtual
4. Series and parallel connection of PV modules, observe mismatch issues. Real-World Assignment: Design a small array for 12V/24V system (e.g., for laptop charging or lab fan). Calculate total power and suggest fuse/ diode protection for mismatch in a multi-panel rooftop installation.
5. Installation and wiring of standalone solar PV system (PV _ Charge controller _ Battery _ Load/Inverter) Real-World Assignment: Prepare a complete wiring diagram and BOM for a 100W system to power a college water cooler or hostel room. Include safety earthing and cable sizing as per real IEC standards.
6. Preventive maintenance: Cleaning, visual inspection, corrosion/loose connection check. Real-World Assignment: Inspect any existing solar panel in college/hostel. Prepare a 6-month maintenance schedule with cost estimation (dust cleaning, tightening)
7. Grid-Related Maintenance Checks for Grid-Tied Solar PV Systems: Inverter Health, Performance Monitoring, and Fault Diagnosis. Real-World Assignment: Survey a real grid-tied installation, prepare a maintenance schedule: Monthly inverter check, quarterly visual, annual professional inspection.
8. Mounting structure assembly: Rooftop/ground mount, tilt adjustment, stability check Real-World Assignment: Design a simple mounting frame for windy Pune conditions. Calculate wind load and suggest material/cost for a 5kW residential installation.
9. IoT-Based Real-Time Solar PV System Monitoring and Performance Dashboard.
10. Industrial Visit to Solar Energy Facility in Pune Region: Hands-On Learning of Solar PV System Operations and Maintenance

Learning Resources

Text Books:

1. S.P. Sukhatme, Solar Energy
2. C.S. Solanki, Solar Photovoltaics
3. D.P. Kothari et al., Renewable Energy Sources
4. G.D. Rai, Non-Conventional Energy Sources
5. H.P. Garg, Solar Energy Utilization

Reference Books:

1. Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers Author: Chetan Singh Solanki.
2. Solar PV System: Design, Installation, Operation and MaintenanceAuthors: L. Ashok Kumar and K. Mohana Sundaram.
3. Solar Engineering of Thermal Processes, Photovoltaics and Wind (5th Edition) Authors: John A. Duffie, William A. Beckman (updated with Nathan Blair).
4. Principles of Solar Engineering (3rd Edition) Authors: D. Yogi Goswami, Frank Kreith, Jan F. Kreider

NPTEL Course:

1. Solar Photovoltaics: Fundamentals, Technology and Applications: https://onlinecourses.nptel.ac.in/noc24_
2. SkillCat or Other Free Solar Training (Installation Focus). https://www.skillcatapp.com/solarinstallation-training

Savitribai Phule Pune University

Third Year of Engineering - Instrumentation & Control Engineering (2024 Pattern)

Course Code: ELC-381-INC **Course Name: Internship**

Teaching Scheme	Credit	Examination Scheme
Practical: 8 Hours/week	04	Term Work: 50 marks

Course Outcomes:

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

1. Apply theoretical knowledge to solve real-world engineering problems.
2. Demonstrate technical competency in tools/technologies used in industry.
3. Exhibit professional ethics and teamwork.
4. Prepare technical reports and deliver effective presentations on industrial training experience.
5. Analyze industrial processes and suggest feasible improvements or innovations.

Guidelines

1. Students should opt for a internship/OJT 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 after V semester and before VI semester, preferably during winter break.
3. **Undergoing a training program / 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. Internship completion will be considered only after submission of valid documents at

the end of internship like completion certificate, internship diary, 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

- Students are expected to perform the following activities during internship:
- 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 and implementation
  - Database design and integration
  - Software testing and debugging
  - API integration and deployment
  - Use of version control systems
  - Documentation practices
- Phase III – Project Execution
  - Module development
  - Testing and validation
  - Performance optimization
  - 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/ diary
- Mid-term progress report
- Supervisor feedback (initial)

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.

Guidelines for Internship Report Writing

11. Preliminary Pages
    - Cover Page
    - Certificate from Organization
    - Certificate from Department
    - Acknowledgement
    - Abstract
    - Table of Contents
12. Chapter 1 – Organization Profile
    - Company overview
    - Vision and mission
    - Products/services
    - Organizational structure
13. Chapter 2 – Problem Statement and Objectives
    - Project title
    - Need of project
    - Objectives
    - Scope

4. Chapter 3 – Technologies and Methodology
    - Software/hardware tools used
    - Development methodology
    - System architecture
    - Database design
5. Chapter 4 – Work Carried Out
    - Tasks completed
    - Screenshots/results
    - Challenges faced

- Solutions implemented

6. Chapter 5 – Learning Outcomes
    - Technical learning
    - Professional skills acquired
    - Industry exposure
    - Future scope
7. Chapter 6 – Conclusion
    - Summary of work
    - Achievements
    - Suggestions

References: IEEE format references preferred

Appendices

- Source code snippets
- Certificates
- Additional screenshots

Learning Resources

Text Books:

1. W. J. King and James G. Skakoon , The Unwritten Laws of Engineering , ASME Press
2. Stuart Walesh, Engineering Your Future: The Professional Practice of Engineering
3. Eliyahu M. Goldratt, The Goal: A Process of Ongoing Improvement
4. AICTE Internship Policy: AICTE Internship Policy: Guidelines & Procedures
5. AICTE Internship Portal : https://internship.aicte-india.org

BoS Coordinator

Dr. Chandrakant Kadu - Board of Studies Instrumentation Engineering

Savitribai Phule Pune University, Pune

Dean

Dr. Raosaheb Latpate - Dean – Science and Technology

Savitribai Phule Pune University, Pune

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BoS Coordinator
Instrumentation Engineering