Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

Curriculum Structure and Syllabus

Master of Engineering (2025 Pattern)

in

ME – Instrumentation and Control Engineering

(Process Instrumentation)

(With effect from Academic Year 2025-26)

Preface

It is with great pleasure and a deep sense of responsibility to present the revised syllabus for the Master of Engineering (Process Instrumentation) program in Instrumentation and Control Engineering. This curriculum has been meticulously framed with a forward-looking perspective, keeping in mind the rapid technological advancements, emerging industrial demands, and the evolving demand of automation, smart systems, and intelligent control technologies.

Instrumentation and Control Engineering stands at the crossroads of multiple engineering disciplines—integrating principles of electronics, mechanical systems, and computer science to design, develop, and implement intelligent systems. In today's era of Industry 4.0 and smart manufacturing, the role of instrumentation and control engineers has expanded significantly. This syllabus revision reflects our commitment to equipping students with the core competencies, practical skills, and innovative mindset required to thrive in such a dynamic and interdisciplinary field.

The syllabus has been developed through a consultative process involving academic experts, industry professionals, and alumni, ensuring a holistic and application-oriented learning experience. Emphasis has been placed on both foundational theories and hands-on exposure to modern tools and platforms such as real-time systems, data analytics applications in control, industrial automation, and advanced signal processing.

Furthermore, the structure promotes interdisciplinary electives, research-oriented projects, and industry collaborations, enabling students to tailor their learning path in line with their career aspirations. We believe this curriculum will foster critical thinking, ethical practices, and lifelong learning—qualities essential for the engineers of tomorrow.

I would like to extend my sincere gratitude to Dr. Pramod D. Patil, Dean, Science and Technology, Savitribai Phule Pune University, Pune and all members of the Board of Studies, faculty contributors, and industry advisors whose valuable insights and contributions have shaped this curriculum. We remain committed to continuous improvement, and we welcome feedback to further enhance the relevance and quality of this program.

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Savitribai Phule Pune University, Pune

Member- Board of Studies

Dr. C. B. Kadu	Coordinator, Board of Studies-Instrumentation Engineering, Pravara Rural Engineering College, Loni
Dr. N. S. Nehe	Government College of Engineering & Research, Avasari, Khurd
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Mr. Vishwas Wakchaure	Schneider Electrical System Mumbai

Program Outcomes (PO)

POs 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, analytical ability attitude and behavior that students acquire through the program.
The POs essentially indicate what the students can do from subject-wise knowledge acquired by them during the program. As such, POs define the professional profile of a graduate of PG Engineering Program.

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

General Rules and Guidelines

1. Students may choose any one course from NPTEL/SWAYAM MOOCs courses for 3 credits as well as produce an award certificate at the end of the respective semester and One credit will be awarded by the assigned mentors through monitoring the students course progress by respective mentors assigned to them for a four-week MOOCs course). Open Elective Course I and II
2. The dissertation stage I and II must result into the publication of at least two research papers (at Stage–I and Stage-II respectively) preferably in the Journal having Citation Index 2.0 and ISSN number; or paper can be published in reputed International Journal/ Conference recommended by the guide of the Dissertation. The guide certificate covering originality of the work and plagiarism-testing result shall be included in the report along with the Published Journal/Conference Papers. The comments received by the journal/conference paper reviewers be attached in the Dissertation report and shall be made available during dissertation presentation/viva to the examiners.
3. Registration for NPTEL/ SWAYAM courses: Students may register for these courses during registration window as per Academic calendar for that semester.
4. Assessments consist of A) In-semester continuous assessment and B) End-semester assessment. Both shall have an approximately equal weight age.
5. Skills Based Lab I & II: The laboratory work will be based on completion of assignments confined to the courses of that semester.
6. Seminar: The student shall deliver the seminar on a topic approved by authorities.
   - Seminar I: Shall be on state-of-the-art topic of student's own choice approved by an authority. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.
   - Seminar II: shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.
   - Seminar III: shall preferably an extension of seminar II. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

7. Project Work:

The project work shall be based on the knowledge acquired by the student during the coursework and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems based on area where the student likes to acquire specialized skills.

- Project Work Stage – I - It is an integral part of the project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation (Mathematical Model/SRS/UML/ERD/block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. As a part of the progress report of Project work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic. The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and

head of the Department/Institute.

- Project Work Stage-II- The student shall complete the remaining part of the project which will consist of the fabrication of set up required for the project, work station, conducting experiments and taking results, analysis & validation of results and conclusions. The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

Note: *Institute must submit the list of candidates, guide and project details (title, area, problem definition, abstract - clearly indicating objectives and scope, sponsorship details, if any) to the university within month of commencement of third semester. The guide must be approved/qualified full-time teacher of the Institute. A guide can accept/enroll at the most 8 students per year.*

Master of Engineering (2025 Pattern)-Instrumentation and Control Engineering (Process Instrumentation)
Semester I

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 I														
PCC-501-PRI	Program Core Course	Transducer Design	4	-	-	50	50	-	-	-	4	-	-	4
PCC-502-PRI	Program Core Course	Industrial Automation	4	-	-	50	50	-	-	-	4	-	-	4
PCC-503-PRI	Program Core Course	Process Modelling and Optimization	4	-	-	50	50	-	-	-	4	-	-	4
PCC-504-PRI	Program Core Course	Mathematical Methods in Instrumentation	4	-	-	50	50	-	-	-	4	-	-	4
PCC-505-PRI	Program Core Course	PG-Lab-1	-	-	4	-	-	50	-	50	-	-	2	2
PEC-521-PRI	Program Elective Course	Elective-I	4	-	-	50	50	-	-	-	4	-	-	4
Total			**20**	**-**	**4**	**250**	**250**	**50**	**-**	**50**	**20**	**--**	**2**	**22**

CCE*: Comprehensive Continuous Evaluation

Elective-I

PEC-521A-PRI	Soft Computing
PEC--521B-PRI	Advanced Power Electronics
PEC--521C-PRI	Robotics

Master of Engineering (2025 Pattern)-Instrumentation and Control Engineering (Process Instrumentation)
Semester II

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 II														
PCC-551-PRI	Program Core Course	Process Dynamics & Control	4	-	-	50	50	-	-	-	4	-	-	4
PCC-552-PRI	Program Core Course	Advanced Embedded System	4	-	-	50	50	-	-	-	4	-	-	4
PCC-553-PRI	Program Core Course	Data Analytics	4	-	-	50	50	-	-	-	4	-	-	4
PCC-554-PRI	Program Core Course	PG Lab-II	-	-	4	-	-	25	-	25	-	-	2	2
PEC-561-PRI	Program Elective Course	Elective-II	3	-	-	50	50	-	-	-	3	-	-	3
PEC-562-PRI	Program Elective Course	Elective-III	3	-	-	50	50	-	-	-	3	-	-	3
TS-571-PRI	Technical Seminar	Seminar-1	-	-	4			25	-	25	-	-	2	2
Total			**18**	**-**	**8**	**250**	**250**	**50**	**-**	**50**	**18**	**-**	**4**	**22**

CCE*: Comprehensive Continuous Evaluation

Elective-II

PEC-561A-PRI	Advanced Control System
PEC-561B-PRI	Batch Process Control
PEC-561C-PRI	Building Automation

Elective-III

PEC-562A-PRI	Industrial Safety
PEC-562B-PRI	Advanced Signal Processing
PEC-562C-PRI	Artificial Intelligence and Machine Learning

Master of Engineering (2025 Pattern)-Instrumentation and Control Engineering (Process Instrumentation)

Semester III

Level 6.5														
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 III														
RM-631-PRI	RM	Research Methodology	4	-	-	50	50	-	-	-	4	-	-	4
OJT-641-PRI	Internship/ OJT (IN/OJT)	Internship/On Job Training	-	-	10	-	-	100	-	-	-	-	5	5
SEM-632-PRI	Technical Seminar	Seminar-2	-	-	8		-	25	-	25	-	-	4	4
RP-642-PRI	Research Project	Research Project-I	-	-	18	-	-	25	-	25	-	-	9	9
Total			**4**	**-**	**36**	**50**	**50**	**150**	**-**	**50**	**4**	**-**	**18**	**22**

Semester IV

Level 6.5														
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 IV														
RP-671-PRI	Research Project	Seminar on Project Stage-II	-	-	8		-	50	-	50	-	-	4	4
RP-681-PRI	Research Project	Research Project Stage-II	-	-	36	-	-	150	-	50	-	-	18	18
Total			**4**	**-**	**42**	**-**	**-**	**200**	**-**	**100**	**-**	**-**	**22**	**22**

CCE*: Comprehensive Continuous Evaluation

** Students are informed to complete the below mentioned courses in **online** mode as per guidelines.

Course Name	Semester	Credits
Human Rights	Semester-1	1
	Semester-2	1
Skill Development	Semester-3	2
	Semester-4	2
Introduction to Cyber Security/ Information Security	Semester -1/2/3/4	4

PCC-501-PRI: Transducer Design

Teaching Scheme:	Credits:	Examination Scheme:
TH : 4 Hrs./Week	**4**	Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes:

1. Classify different types of sensors and actuators based on transduction principles.
2. Evaluate and analyze the static and dynamic characteristics of transducers, recognizing and rectifying errors in measurement.
3. Demonstrate the application of signal conditioning techniques in the design of transducers through practical examples and case studies.
4. Design and analyze micro sensors, such as accelerometers, pressure sensors, and strain gauges, incorporating MEMS technology for improved performance and efficiency.

Module-I: Review of Transducers: Introduction to Transducers, Sensors and Actuators. Transduction Principles and Classification. Static and Dynamic Characteristics of Transducer. Errors in Measurement and their remedial measures, Propagation of Errors.

Module-II: Signal Conditioning: Concept of signal conditioning, signal level and bias changes, linearization, conversation, filtering and impedance matching, concept of loading, divider circuits, and bridge circuits, comparators, ADC, DAC, interference, grounding, and shielding.

Module-III: Chemical Sensors: Bio sensors, Gas Sensors, Optical gas sensor Piezoelectric gas sensor; Case Study: Biosensors for monitoring water pollutants

Module-IV: MEMS Sensors: Fundamentals of stress-strain, electrostatics and energy dissipation, Si and its properties; Micro-fabrication and lithography

Module-V: Design and fabrication process of Micro sensors: Design and analysis of Micro Sensors; Case study: Accelerometer, Pressure sensor and Strain gauge

Module-VI: Biomedical Instrumentation & Sensors: Introduction to Biomedical Instrumentation and Sensors, Human Anatomy and Physiology relevant to Biomedical Instrumentation and Sensors, Types of Biomedical Sensors (Optical, Chemical, Electrical), Biomedical sensor cardiovascular and nervous system.

Reference Books:

1. Micro and Smart Systems, G. K. Anantha Suresh
2. Micro system Design by Stephen D Senturia, Publisher: Springer US, 1st ed. 2000. Corr. 2nd printing 2004 edition
3. Biomedical Sensors and Instruments, Second Edition by Tatsuo Tagawa, Toshiyo Tamura, P. Ake Oberg
4. Sensors and Signal Conditioning Wiley-Blackwell, 2008 Jacob Fraden, Handbook of modern sensors, Springer, Stefan Johann Rupitsch.
5. M Fundamentals of Microfabrication, CRC Press, 1997.
6. E.O. Doebelin, Measurement Systems - Application and Design, Fourth edition, McGraw- Hill International Edition, New York.
7. C.S. Rangan, G.R. Sharma and V.S.V. Mani ‘Instrumentation Devices and Systems’, Tata Mcgraw-Hill Publishing Company Ltd. New Delhi.
8. Curtis D. Johnson, “Process control instrumentation technology” 8th ed. PHI learning Pvt. Ltd., 2010.5. J. Wilson, ‘Optoelectronics’, 2nd Edition, (Prentice-Hall, India) (1999).
9. D. Patranabis, “Sensors and Transducers”, 2nd Edition, (Prentice-Hall, India).

PCC-502-PRI: Industrial Automation

Teaching Scheme:	**Credits:4**	**Examination Scheme:**
TH: 4 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes:

1. Identify the key components of PLC programming and languages: Ladder Logic (LD), Function Block Diagram (FBD), Structured Text (ST), and Sequential Function Chart (SFC).
2. Compare and contrast various industrial communication protocols such as PROFIBUS, MODBUS, PROFINET, and Ether CAT in terms of application and functionality.
3. Execute DCS programming through function blocks and sequential control to manage complex industrial processes efficiently.
4. Implement HMI and SCADA systems to monitor and control industrial processes effectively, incorporating alarm management, data logging, and report generation.

Module- I: PLC Programming and Languages (IEC 61131-3)

Ladder Logic (LD), Function Block Diagram (FBD), Structured Text (ST), Sequential Function Chart (SFC), Timers, Counters, Analog programming, PID Control, Data Handling instruction.

Module-II: Industrial Communication & Networking

Industrial Communication Protocols: Fieldbus Protocols: PROFIBUS, FOUNDATION Fieldbus, Modbus RTU/TCP, Device Net, **Industrial Ethernet:** PROFINET, Ether Net/IP, Ether CAT, Digital Twin Technology in Industrial Automation. **Cybersecurity in Industrial Networks:** Risks and Threats in Industrial Automation Networks, IEC 62443 for Industrial Control System Security.

Module-III: Distributed Control Systems (DCS)

DCS Programming & Implementation: Function Blocks, Sequential Control, Batch Processing, Integration with ERP, MES. **Advanced Process Control (APC) tools.** One industrial case study.

Module-IV: HMI & SCADA Systems

SCADA: Programming techniques for: Creation of pages, sequencing of pages, creating graphics & Animation & development of application using SCADA System. Alarm Management, Data Logging, and Report Generation, HMI Development: Touch Screens, Web-Based HMI.

Module-V: Industrial IToT& Edge Computing

Challenges and Benefits of IT/OT Integration, IT vs. OT: Key Differences and Similarities, Cybersecurity in IT/OT Systems, Integration of Edge Devices and Cloud-Based Industrial Control, Digital Twin Technology in Industrial Automation.

Module-VI: Industry 4.0 & Smart Manufacturing

Industrial Automation in the Digital Age, AI & Machine Learning in Process Automation.
Case Studies: Smart Manufacturing in Automotive & Aerospace Industries.

Reference 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.
5. B.G. Liptak, Process software and digital networks, CRC press, Florida.
6. Practical Distributed Control Systems for Engineers and Technicians-IDC technologies.
7. Programmable Logic Controllers – Frank D. Petruzella
8. Programmable Logic Controllers: Principles and Applications – John W. Webb & Ronald A. Reis
9. Introduction to Programmable Logic Controllers – Gary A. Dunning
10. HMI and SCADA: Theory and Practice – Stuart A. Boyer

11. Edge Computing: Fundamentals, Advances and Applications- K. Anitha Kumari, G. Sudha Sadasivam, D. Dharani, M. Niranjana murthy.
12. Industrial Internet of Things: Technologies and Research Directions-Anand Sharma, Sunil Kumar Jangir, Manish Kumar, Dilip Kumar Choubey, Tarun Shrivastava, and S. Balamurugan
13. Smart Manufacturing: The Future of Manufacturing Work – Evan L. Shellshear

PCC-503-PRI: Process Modelling and Optimization

Teaching Scheme:	**Credits:4**	**Examination Scheme:**
TH: 4 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Identify the key principles of first and second-order models in various systems.
2. Analyze the dynamic models of representative processes such as reaction dynamics and balance equations.
3. Utilize numerical algorithms for subspace state space identification and least square method in process identification.
4. Analyze the characteristics of multivariable systems using open-loop and closed-loop equations.

Module- I: Introduction to Modeling: Introduction to Models, Use of Models, Scope of Models, Types of models, modeling of process control systems in time domain and frequency domain, General modeling principles, first and second order models, higher order models, modeling of first and second order electrical systems, mechanical systems, Degree of freedom Analysis.

Module- II: Dynamic Models of Representative Processes: Reaction dynamics, Balance equations, modeling of Two tanks in series and in parallel, CSTR models, Plug flow reactor model, modeling of flash drum, distillation columns, evaporators, dryers, heat exchangers, Batch reactor.

Module- III: Numerical Methods: Solution of algebraic equation: Interval Halving, Newton Raphson method Solution of differential equation: Runge-Kutta method, Euler method, Adam Bash forth method

Module- IV: Process Identification: Identification of physical processes, off-line and on-line identification, Step testing, pulse testing, sine wave testing, ATV identification method, prediction error methods, introduction to numerical algorithm for subspace state space identification, least square method, Relationships among time, Laplace and frequency domain.

Module- V: Basic Concepts of Optimization: Scope of Optimization, Development of Models for optimization, Continuity of functions, convex and concave functions, Convex Region, Extremum of the objective functions, quadratic approximation.

Module- VI: Optimization of Constrained and Unconstrained functions: Constrained optimization – direct method, Constrained optimization – indirect method, Unconstrained optimization with single variable, Unconstrained optimization with multiple variables.

References:

1. W. L. Luyben, Process, Modeling, Simulation and Control for Chemical Engineers by McGraw Hill, 1973
2. Thomas Edgar, David Himmel blau, Optimization of Chemical Processes, Second edition, McGraw Hill, 2001.
3. W. F. Stoecker, Design of Thermal Systems International Education, McGraw hill 1989.
4. J. Malley, Practical Process Instrumentation and Control ı McGraw Hill.
5. Deo Narsingh ,System Simulation with digital Computer ı Prentice Hall India, New Delhi.
6. Singiresu S. Rao, Engineering Optimization (Therory & Practice),third Edition, New Age International (p) Ltd, Publishers.
7. Dale E. Seborg, T. F. Edgar and D. A. Mellichamp, Process Dynamics and Control, John Willey and Sons publication.

PCC-504-PRI: Mathematical Methods in Instrumentation

Teaching Scheme:	**Credits:4**	**Examination Scheme:**
TH: 4 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Define vector spaces, subspace, linear transformations, inner products, and norms, and apply these concepts to solve problems in instrumentation.
2. Implement numerical methods such as least square method, Gauss-Jordon method, and Runge-Kutta methods to solve algebraic and differential equations in instrumentation.
3. Interpret and analyze probability distributions like Binomial, Normal, Poisson, and uniform distributions to make informed decisions in instrumentation applications.
4. Create mathematical models for calculating mathematical expectations, mean, variance, covariance, and correlation in instrumentation scenarios.

Module- I

Vector Spaces and Transformation: Vector spaces, subspace and linear dependence, concept of basis, representation, norms of vectors and orthonormalization, linear transformations, concept of symmetry, inner products, singular value decomposition.

Module- II

Orthogonal and Unitary Transformation: Orthogonal projections, products of projections, orthogonal direct sums, Unitary and orthogonal transformations, closed subspaces and the projection theorem for Hilbert spaces

Module- III

Numerical method for algebraic and differential equations: Least square method, Gauss-Jordon method, Gauss-Seidal method, Gauss elimination method, Newton-Raphson method, Euler's method, modified Euler's method, Runge-Kutta methods, Adam-Bash forth method.

Module- IV

Basic concept of Probability: Random experiments, sample spaces, axioms of probability conditional probability, Bayes theorem.

Module- V

Probability distributions: Probability distribution function, probability density function, Binomial, Normal, Poisson and uniform distribution

Module- VI

Mathematical expectations: Mean variance, standard deviation, moments, covariance and correlation.

References:

1. Chen C. T., 'Linear Systems: Theory & Design', Oxford University Press New York-1999.
2. Charles W. Curtis, 'Linear Algebra: An Introductory Approach', Springer (India) Pvt. Ltd.
3. Strang G., 'Linear Algebra And Its Applications'. Thomson Brooks, Australia-1998.
4. Lay D. C., 'Linear Algebra and Applications', (Addison Wesley, Massachusetts), (1996).
5. Gilbert Jimmie and Gilbert Linda, 'Linear Algebra and Matrix Theory', (Elsevier India Publishing Co., New Delhi), 2005.
6. Grewal B. S., 'Higher Engineering Mathematics', (Khanna Publishers, New Delhi), (2004).
7. Rajaraman V., 'Computer Oriented Numerical Methods'. (Prentice Hall of India New Delhi),
8. Murray Spiegel, John Schiller and R. Alu Srinivasan, 'Probability and Statistics', (Tata McGraw- Hill edition, New Delhi).
9. Miller I & Freund J., 'Probability & Statistics For Engineering'. (Prentice Hall Of India New Delhi), (1987).
10. Walpole R. E., Myers R. H. & Myers S. L., 'Probability & Statistics For Engineers & Scientist'.(Prentice Hall Inc. New Jercy

PCC-505-PRI :PG-Lab-1		
Teaching Scheme: Practical: 4 Hrs./Week	**Credits:2**	**Examination Scheme:** (TW: 50marks, OR: 50marks)

Course Outcomes

1. Execute experiments independently in the lab.
2. Organize and relate experimental data to theoretical concepts accurately.
3. Analyze and interpret experimental results to draw meaningful conclusions.
4. Solving complex problems using acquired analytical skills.

Lab practice should be based on the course work. The number of hours is fairly distributed among the number courses, for which the practical work is necessary. The objective of the lab practice is to develop analytical skill and problem tackling skills. Also, it is expected that the students must learn to use the latest Instrumentation tools, so that the industry will get trained Engineers.

PEC-521A-PRI: Soft Computing

Teaching Scheme:	Credits:3	Examination Scheme:
TH : 3 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Implement neural network models to classify data accurately and efficiently.
2. Demonstrate the ability to design and evaluate fuzzy logic systems for decision-making processes.
3. Analyze and apply concepts of Fuzzy Logic and Genetic Algorithms to tackle real-world optimization problems effectively.
4. Execute soft computing techniques to solve practical problems in the domain of computational intelligence.
5. Evaluate the suitability and effectiveness of different soft computing techniques in various applications.

Module-I: Soft Computing: Conventional AI to Computational Intelligence, Soft Computing Constituents and Applications.
Data Clustering Algorithms: K-Means, Fuzzy C-Means, Mountain Clustering, Subtractive Clustering.

Module-II: Neural Networks: Fundamental Concepts, Basic Models and Architecture, Machine Learning using Neural Networks, Associative Memory Networks and their Applications.

Module-III: Supervised Learning Neural Networks: Perceptron Networks, Radial Basis Function Networks: Back Propagation Neural Network: Architecture, Learning, Applications, & Research Directions; The Boltzmann Machine.
Unsupervised Learning Networks: Competitive Learning networks; Kohonen Self-Organizing Networks; Hebbian learning; The Hopfield Network; Counter propagation Networks; Adaptive Resonance Theory: Introduction, Architecture, & Applications; Feed forward Networks; Reinforcement Learning.

Module-IV: Fuzzy Logic: Fuzzy set theory, Fuzzy set versus crisp set, Crisp relation & fuzzy relations **Membership Functions:** Introduction, Features, &Fuzzification, Methods of Membership Value Assignment; Defuzzification.
Fuzzy Systems: Crisp Logic, Predicate Logic, Fuzzy Logic; Fuzzy Rule Base and Approximate Reasoning, Fuzzy Quantifiers; Fuzzy Inference Systems, Fuzzy Decision Making, Fuzzy Logic Control System; Fuzzy Expert Systems.

Module-V: Genetic Algorithms: Introduction to Genetic Algorithms (GA) and their Terminology; Traditional Optimization and Search Techniques vs. Genetic Algorithm; Operators in Genetic Algorithms; Problem Solving using Genetic Algorithm; Classification of Genetic Algorithms; Genetic Programming; Advantages and Limitations of Genetic Algorithm; Applications of Genetic Algorithm; Applications of GA in Machine Learning.

Module-VI: Optimization: Derivative-based Optimization, Descent Methods, The Method of Steepest Descent, Classical Newton's Method, Simulated Annealing, Random Search, Downhill Simplex Search Derivative-free Optimization- Genetic algorithm Fundamentals, basic concepts, working principle, encoding, fitness function, reproduction, Genetic modeling: Inheritance operator, cross over, mutation operator, Generational Cycle.

Reference Books:

1. N.P. Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press.
2. Kosco B, "Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence", Prentice Hall of India, New Delhi, 1992.
3. Kumar Satish, "Neural Networks", Tata Mc-Graw Hill.
4. Bose and Liang, Artificial Neural Networks, Tata Mc-Graw Hill.
5. Ross, Timothy J., Jane M. Booker, and W. Jerry Parkinson, eds. *Fuzzy logic and probability applications: bridging the gap*.

PEC-521B-PRI: Advanced Power Electronics

Teaching Scheme: TH : 4 Hrs./Week	Credits:4	Examination Scheme: Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Identify different types of controlled rectifiers and their operation principles.
2. Describe the operation and design considerations of various DC-DC converters, including buck, boost, and Cuk converters.
3. Analyze the working of inverters, including 1-ø and 3-ø voltage source inverters, and evaluate their performance in different applications.
4. Create innovative solutions in power electronics for renewable energy sources and power conditioning, integrating concepts like soft switching, resonant converters, and high frequency magnetic component design.

Module I: Controlled Rectifiers

1-ø controlled rectifiers, Line commutated 1-ø controlled rectifiers, Unity power factor 1-ø rectifiers, 3-ø controlled rectifiers, Line commutated 3-ø controlled rectifiers, Force commutated 3-ø controlled rectifiers.

Module II: DC – DC Converters

DC Choppers, Buck Converters, Boost Converters, Cuk Converters, Multi-quadrant ZCS Quasi Resonant Lio Converters, Multi-quadrant ZVS Quasi Resonant Lio Converters, Synchronous-rectifier DC/DC Lio-converters.

Module III: Inverters

1-ø voltage source inverters, 3-ø voltage source inverters, Current Source Inverters, Closed loop operations on inverters, Regeneration in Inverters, Multistate Inverters.

Module IV: Resonant converters and Power supplies:

Concept of Soft switching, Resonant converter Analysis and Design. SLR, PLR, ZCS, ZVS Converter analysis and Design. Synchronous rectifiers, Low Dropout Regulators, Hot Swappable Redundant Power Supplies, Design of High Frequency magnetic components for converters, Bi-Directional Power Supplies

Module V: Power Electronics for Renewable Energy Sources:

Power Electronics for Photovoltaic Power System, Power Electronics for Wind Power System, variable wind energy conversion system with DC-to-Dc converters followed by 3Phase VSI, Photo voltaic energy conversion system, Solar Battery powered drives, traction drives, energy conversion in electrical drives, Battery Chargers.

Module VI: Power Conditioning:

Power quality, power line disturbances and its remedies, energy audit, solar power conditioning, Power transmission. FACTS Flexible AC Transmission, HVDC.

Text Books:

1. Power Electronics by M. H. Rashid, 2nd Edition, PHI.
2. Power Electronics by P. C. Sen, TMH.
3. An Introduction to Thyristors and Their Applications by M. Rammurthi (TMH).
4. Electronics in Industry by Chute and Chute.
5. Thyristor Phase control Converters and Cyclo converters by B. R. Pelly.
6. Power Supplies by B. S. Sonde.
7. Power Electronics by Dev.

PEC-521C-PRI: Robotics

Teaching Scheme:	Credits:4	Examination Scheme:
TH : 4 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Demonstrate the ability to identify and describe the basic components and performance characteristics of robots.
1. Interpret and evaluate the significance of actuators, sensors, and vision systems in enhancing robotic functionalities.
2. Solve control problems in robot manipulators using different techniques.
3. Execute end effect or selection and motion control techniques to achieve desired tasks within a robotic workspace.
5. Organize and execute complex robotic tasks by integrating the principles of motion analysis, kinematics, and dynamics in robot applications.

Module-I: Robotics: Basic components, Classification, Performance characteristics, degrees of freedom, degrees of movements, robot configuration, definition and factor affecting the control resolution, spatial resolution, accuracy and repeatability, specification of a robot
Actuators- Electric actuator, DC motor horse power calculation, magneto strictive hydraulic and pneumatic actuators.

Module-II: Sensors and vision systems: Different types of robot transducers and sensors, Tactile sensors, Proximity and range sensors, ultrasonic sensor, touch sensors, slip sensors, sensor calibration, vision systems, Image processing and analysis, image data reduction, segmentation feature extraction, Object recognition.

Module-III: Robot Control: Control of robot manipulators, state equations, constant solutions, linear feedback systems, single axis PID control, PD gravity control, computed torque control, variable structure control, Impedance control.

Module-IV: End effectors and tools: types, Mechanical grippers, Vacuum cups, Magnetic grippers, Robot end effectors interface, work space analysis work envelope, workspace fixtures, pick and place operation, continuous path motion, interpolated motion, straight line motion.

Module-V: Robot motion analysis and control: Manipulator kinematics, forward and inverse kinematics, arm equation, link coordinates, Homogeneous transformations and rotations and Robot dynamics.

Module-VI: Robot Applications: Industrial and Non industrial robots, Robots for welding, painting and assembly, Remote Controlled robots, Robots for nuclear, thermal and chemical plants, Industrial automation, Typical examples of automated industries.

Reference Books

1. 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, 2012.
2. K.S. Fu, R.C. Gonzales, C.S.G. Lee, “Robotics: Control, Sensing, Vision and Intelligence”, McGraw Hill, 1987.
3. John J. Craig, “Introduction to Robotics (Mechanics and Control)”, Addison-Wesley, 2nd Edition, 2004.

Semester-II

PCC-551-PRI: Process Dynamics and Control

Teaching Scheme:	**Credits:4**	**Examination Scheme:**
TH : 4 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes:

1. Execute a comprehensive understanding of the fundamentals of process control.
2. Implement closed-loop oscillation-based tuning methods and apply tuning rules for first-order + dead time processes.
3. Analyze model uncertainty and disturbances, and apply the Internal Model Control (IMC) structure for designing controllers.
4. Evaluate the effectiveness of cascade control, inferential control, and feed-forward control in improving process performance.

Module- I: Introduction to Process Control

Review of basics of Process Control, Control objective and benefits, control system elements. Controller and analysis of closed loop system, P, PI, PID controller, Stability Analysis

Module- II: Controller Tuning

Closed-Loop Oscillation-Based Tuning, Tuning Rules for First-Order + Dead Time Processes, Direct Synthesis, Robustness

Module- III: Model Based control

Introduction to Model-Based Control, Open-Loop Controller Design, Model Uncertainty and Disturbances, IMC Structure, IMC Design Procedure, Improving Disturbance Rejection Design, IMC-Based PID controller for Delay-Free and Time Delay Processes

Module- IV: Advanced Process control:

Cascade control, inferential control, override control, selective control, slit range control, Feed Forward Control, Feedback-feed forward and Ratio control

Module- V: Multivariable control

Introduction to Multivariable controllers. The Relative Gain Array, Properties and Application of the RGA, Sensitivity, Decoupling control

Module- VI: Model Predictive Control:

Introduction to Model Predictive Control: General Principles, Model forms, DMC, SISO unconstrained DMC Problem, controller tuning.

Process Monitoring: Statistical Process Control-control charts and its interpretation, multivariate charts and controller, performance monitoring.

References:

1. Thomas E. Marlin ‘Process Control’, (McGraw-Hill International 2nd Edition)
2. Jose A. Romagnoli, Ahmet Palazoglu, ‘Introduction to process Control’ (CRC Taylor and Francis group)
3. B. Wayne Bequette,’Process Control’, (Printice Hall of India Pvt. Ltd)
4. B.G. Liptak, ‘Handbook of Instrumentation- Process Control’
5. D. Seborg, T. F. Edgar, D. A. Mellichamp,’ Process Dynamics and Control’ (2nd Edition WILEY INDIA).
6. J. Nagrath, M.Gopal, ‘Control System Engineering’, (New Age Publication 3 rd Edition).

PCC-552-PRI: Advanced Embedded System

Teaching Scheme:	Credits:4	Examination Scheme:
TH : 4 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Analyze the RISC design philosophy and different ARM microcontroller families.
2. LED, stepper motor, LCD display, and other external devices interfacing with ARM microcontrollers.
3. Demonstrate the application of various serial communication protocols, including UART, SPI, I2C, and CAN.
4. Evaluate real-world case studies in Embedded Systems and demonstrate a thorough understanding of their design principles and applications.

Module I: Introduction to ARM Microcontroller

RISC and ARM design philosophy, ARM family, ARM Core &Architecture – Arithmetic Logic Unit, Booth multiplier, Barrel shifter, Control unit, register file, ARM Functional Diagram, Pipeline Characteristics, ARM Instruction set, Thumb-2 technology and applications of ARM, Architecture of ARM Cortex M3, Various Units in the architecture, General Purpose Registers, Special Registers, exceptions, interrupts, stack operation, reset sequence, ARM Instruction Set – Thumb Instruction Set.

Module II: Bus Technology and ARM7 Microcontroller

ARM Bus technology, AMBA Bus Protocol, Memory Controllers, Interrupt Controllers - Standard interrupt controller (SIC), Vector interrupt controller (VIC). ARM7 LPC2148 Microcontroller Architecture, Block Diagram, Features, Memory Mapping, serial communication interface – USB 2, full speed device, multiple UARTs, SPI, SSP to 12C. 32-bit timers,10-bit DAC,10-bit ADC, PWM channel, fast GPIO lines and level sensitive external interrupts pins.

Module III: Interfacing with external world

Interfacing of LED with LPC2148, interfacing of four digit 7-segment common anode multiplexed LED display with LPC2148, interfacing of 16x2 LCD display (8-bit) with LPC2148, interfacing of stepper motor with LPC2148, Interfacing of DC motor using L298 with LPC2148, Interfacing of electromechanical relay with LPC2148, LPC 2148 interfacing with On-Chip (Internal) ADC. Interfacing of GPS module with LPC2148, Interfacing of Bluetooth module with LPC2148, Serial Communication Using UART in LPC2148, Interfacing EEPROM IC(AT24CXX) with LPC2148, SD card Interfacing with LPC2148.

Module IV: Embedded Communication Protocols

Embedded networking introduction, Serial/Parallel communication, serial communication protocols, **UARTs:**RS-232, RS485, serial peripheral interface (SPI), quad SPI, **I^2C:** Data Transfer, Arbitration, Addressing, **CAN:** Architecture, Signalling, Arbitration, Framing, Bit Stuffing, **USB Bus:** Introduction, speed identification on the bus, USB states, USB bus communication, packets, data flow types, enumeration, descriptors. CAN bus: Introduction, frames, bit stuffing, types of errors, nominal bit timing. PC parallel port programming, ISA/PCI bus protocols, firmware.

Module V: Case Studies: Case Studies: Design and discussion of specific examples of complete embedded system in application areas of Process Control System, Biomedical Instrumentation, and Communication: IoT Based Systems

Module VI: Case Studies: Case Studies: Design and discussion of specific examples of complete embedded system in application areas of automotive, solar energy and building automation

Text Books:

1. Arm System-on-chip Architecture, 2nd Edition 2015, Steve B. Furber, Pearson.
2. Microcontroller (ARM) and Embedded Systems, Raghunandan G. H., Cengage Learning India Pvt. Ltd., 2020.
3. ARM Assembly Language: Fundamentals and Techniques, Second Edition 2014, William Hohl, CRC Press.

4. A Getting Started Guide for MDK Version 5, Keil.

Reference Books:

1. Embedded Systems Fundamentals with Arm Cortex-M based Microcontrollers: A Practical Approach, Alexander G. Dean, ARM Education Media.
2. ARM Architecture Reference Manual, Second Edition, David Seal, Addison-Wesley.
3. ARM System Developer's Guide: Designing and Optimizing System Software, Andrew Sloss, Dominic Symes, Chris Wright, Morgan Kaufmann.

PCC-553-PRI: Data Analytics

Teaching Scheme:	Credits: 4	Examination Scheme:
TH : 4 Hrs./Week		Theory: 100 marks (Insem: 50 marks + Endsem: 50 marks)

Course Outcomes

1. Describe the five V's of Big Data and explain the lifecycle model of big data.
2. Identify the drivers for Big Data and evaluate market and business drivers for Big Data Analytics.
3. Implement distributed and parallel computing for Big Data using technologies like Hadoop and Apache Spark.
4. Utilize programming languages such as Python for data pre-processing and analytics types.

Prerequisites: Data science, IoT, Data Structures, Machine learning.

Module I: Introduction to Industrial Big Data and Analytics:

Nature and structure of process data: time-series, event-based, setpoint and control loop data. Introduction to Big Data for process industries. Limitations of conventional SCADA/Historian-based analysis. Intelligent data analysis for control systems and Instrumentation. Four V's of Big Data in instrumentation: Volume (sensor data), Velocity (real-time measurements), Variety (process vs control data), Veracity (sensor noise/errors). Role of analytics in safety, predictive maintenance, anomaly detection. Tools overview: Data historians (OSI PI, Wonder ware), Python for Instrumentation.

Module II: Stream Data Analytics in Control Systems

Streaming architectures for control data. Data stream models: Sensor buses, MQTT, OPC-UA, and real-time protocols. Event detection and filtering from sensor noise. Stream sampling and aggregation: Down-sampling, moving average, EWMA for control loops. Real-time analytics for process alarms, fault detection, and batch monitoring. Case studies: Early detection of process faults, compressor surge detection, predictive pump failure.

Module III: Distributed Storage and Processing of Process Data

Overview of distributed file systems for industrial data. Hadoop in industrial context: Integration with data historians and control systems. HDFS: architecture, use for archival of sensor data. Map Reduce for process event classification, batch process analysis. Case studies: Large-scale log analytics from DCS/PLC data.

Module IV: Real-Time Industrial Analytics Using Apache Spark

Overview of Spark and its relevance to industrial analytics. Spark with time-series and process datasets. Data Frames and Spark SQL for sensor data querying. Use of Spark Streaming with Kafka/OPC-UA for control loop analytics. NoSQL for Instrumentation metadata (MongoDB, HBase use cases in asset management).

Module V: Scalable Algorithms for Instrumentation Applications

Anomaly detection in sensor networks and control loops. Similarity analysis in temperature/pressure profiles. Clustering techniques for operating modes in process systems. Machine learning algorithms for sensor validation and virtual sensing. Map Reduce and Spark ML lib-based models for predictive maintenance.

Module VI: Industrial Frameworks, Security and Visualization.

Data pipelines for process data: Edge-to-cloud architectures. Pig and Hive for structured analysis of process batches. Role of HBase and Zookeeper in DCS/SCADA data management. Visualization dashboards: Grafana, Power BI, Tableau for control room analytics. Data security, compliance (IEC 62443), and audit trail in Instrumentation networks.

Reference Books:

1. Maheshwari Anil, Rakshit, Acharya, “Data Analytics”, McGraw Hill, ISBN:789353160258.
2. David Dietrich, Barry Hiller, “Data Science and Big Data Analytics”, EMC education services, Wiley publications, 2012, ISBN0-07-120413-X.

3. LuísTorgo, “Data Mining with R, Learning with Case Studies”, CRC Press, Talay and Francis Group, ISBN9781482234893.
4. B. G. Lipták, Instrument Engineers' Handbook, Process Control and Optimization, CRC Press.
5. RajkumarBuyya et al., Big Data: Principles and Paradigms, Morgan Kaufmann.
6. Jules J. Berman, Principles of Big Data: Preparing, Sharing, and Analyzing Complex Information, Morgan Kaufmann.
7. Dr.Subhas Chandra Mukhopadhyay, Internet of Things: Challenges and Opportunities, Springer.
8. Tom White, Hadoop: The Definitive Guide, O’Reilly.
9. Anand Rajaraman and Jeffrey Ullman, Mining of Massive Datasets, Cambridge University Press.
10. Holden Karau et al., Learning Spark: Lightning-Fast Data Analytics, O'Reilly.
11. SriniPenchikala, Practical Big Data Analytics, Packt Publishing.
12. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer.
13. Montgomery, D.C., Introduction to Statistical Quality Control, Wiley.
14. John Davies, The Enterprise Big Data Lake: Delivering the Promise of Big Data and Data Science, O’Reilly.
15. William Stallings, Data and Computer Communications, Pearson (for secure data handling in control networks).

PCC-554-PRI:PG Lab-II		
Teaching Scheme: PR : 4 Hrs./Week	**Credits:2**	**Examination Scheme:** (TW: 50 marks, OR: 50marks)

Course Outcomes

1. Operate advanced laboratory instruments to conduct experiments accurately and efficiently.
2. Analyze experimental data to draw conclusions and make recommendations.
3. Implement problem-solving strategies to troubleshoot equipment and experimental procedures.
4. Collaborate with peers to plan, execute, and analyze laboratory experiments effectively.

Lab practice should be based on the course work. The number of hours is fairly distributed among the number courses, for which the practical work is necessary. The objective of the lab practice is to develop analytical skill and problem tackling skills. Also, it is expected that the students must learn to use the latest Instrumentation tools, so that the industry will get trained Engineers.

PEC-561A-PRI: Advanced Control System		
Teaching Scheme: TH : 3 Hrs./Week	**Credits:3**	**Examination Scheme:** Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Design compensators using lead, lag, and lag-lead techniques for improving system stability and performance.
2. Analyze the behavior of non-linear systems using describing function analysis and interpret phase plane trajectories.
3. Design state variable feedback controllers and state observers for control system stability and performance.
4. Analyze stability and performance of sampled data and discrete-time control systems.
5. Apply optimal control techniques to optimize system performance and design optimal state regulators.

Module I: Linear System Design: Design of Compensator, Lead, Lag and Lag-Lead Design. PI, PD and PID Controller Design. Feedback Compensation

Module II: Non-Linear Systems: Introduction to Nonlinear System**,** describing function, Describing Function of Dead Zone and saturation non-linearity, Describing Function of relay with dead zone and Hysteresis, Describing Function of Backlash Nonlinearity, Describing function analysis of Nonlinear System. Phase Plane and Phase Trajectory.

Module III: Analysis and Design of Control Systems in State Space: Eigen values and Eigen vectors, Similarity Transformation, Cayley Hamilton Theorem, Transformation of State Model, Control System Design by state variable feedback, Pole Placement approach, State Observer and Design of different state observer.

Module IV: Sampled Data Control System: Introduction, sampling Process, TF of LDS system, Analysis of Sampler and ZOH, Analysis with impulse sampling, Analysis of Sampled Data Control System, Z- domain to S-domain relationship, stability analysis of sampled data control system.

Module V: State Space Analysis of Discrete time control system: Discretization of Continuous time state space Equation, Similarity Transformation, Pulse transfer function Matrix, solution of state difference equations, Controllability and stability, Observability and detect ability, effect of sampling on Controllability and observability, Multivariable systems.

Module VI: Optimal Control: Constrained Optimization, Unconstrained optimization, Concept of Optimal Control, Quadratic Performance index, steady state optimal Control, Optimal state Regulators, linear quadratic Regulator, free final state, Hamiltonian Systems.

Reference Books:

1. Discrete Time Control systems by K. Ogata, Prentice Hall, Second Edition, 2003.
2. Digital Control and State Variable Methods by M. Gopal, Tata McGraw Hill, 2003.
3. Digital control of Dynamic Systems by G.F.Franklin, J.David Powell, Michael Workman
1. 3rd Edition, Addison Wesley.
2. I. J. Nagrath, M. Gopal, Control System Engineering, New Age International Publication,
3. Fifth Edition.
4. M. Vidyasagar, Nonlinear System Analysis, Prentice-Hall Inc. Englewood cliffs, New
5. Jersey 1978.
6. Digital Control Engineering, Analysis and Design ,2nd Edition by M. Sami Fadali,AntonioVisioli, Elsevier Publication, ISBN 978-0-12-394391-0

PEC-561B-PRI: Batch Process Control		
Teaching Scheme: TH : 4 Hrs./Week	**Credits: 4**	**Examination Scheme:** Theory: 100 marks (Insem: 50 marks + Endsem: 50 marks)

Course Outcomes

1. Demonstrate the ability to classify and describe various batch models based on their characteristics.
2. Interpret and analyze batch control activities and functions in a given scenario, including recipe management and production planning.
3. Use safety interlocking systems and sequential control techniques in batch processes to ensure operational efficiency and personnel safety.
4. Solve complex problems related to batch reactor temperature control, distillation, and drying processes for maximizing product recovery and quality.

Module-I: Review of Batch Process:
Introduction to Batch Control System, Batch Process Classification, Batch Models

Module-II: Introduction to Batch Processing:
Batch control types & components. Batch control system terminology & characteristics of batch processing. The hierarchical batch model & control structure.

Module-III: Batch Control Activities and Functions:
Recipe management, Production planning and scheduling, Production information management, Process management & Personnel and environmental protection.

Module-IV: General Control Requirements of Batch Process:
Safety interlocking, sequential control of batch processes, batch & recipe management. Case studies of use in Pharma & Dairy processing.

Module-V: Batch Control Standards:
Recipes, computer aided formulations, electronic batch recorder & signatures, batch control optimization, batch control system selection criteria.

Module-VI: Batch Reactor:
Temperature Control, Auxiliary Cooling, manipulating feed & product rates, Batch Distillation: Constant distillate rate, constant composition control, Maximizing product recovery. Batch drying: Rate of drying, Heat recovery. Selections of Controller for Batch Process. Batch Control function, Safety Interlocking.

Reference

1. Bella G Liptak, 'Instrument Engineer' Handbook, Vol '3' ,3rd edition, (CRC Press) (2002).
2. F. G. Shinskey 'Process Control System',3rd edition, (Mc Graw -Hill International Edition)
3. T. G. Fisher "Batch Control System", ISA Series, 2nd edition,2010
4. B. Roffel and P. Chin, "Batch and Continuous Process Control," Computer Control in the Process Industries, pp. 59–70, Jul. 2017, doi: 10.1201/9781315150482-6.

PEC-561C-PRI: Building Automation

Teaching Scheme:	Credits:3	Examination Scheme:
TH : 3 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Identify the different types of Fire Alarm Systems and their applications.
2. Implement effective fire alarm detection systems based on specified. requirements.
3. Interpret and explain the components and benefits of smart building and security systems, particularly access control technologies.
4. Demonstrate an understanding of HVAC Systems and Air Handling Units by analyzing their components and operations.

Module-I: Introduction to Fire Alarm System

Fire alarm System-The History, Need for Fire alarm System, Classification of Fire Alarm System, Conventional Fire Alarm System, FAS architecture, Addressable Fire Alarm System, Principles of Operations, Its Applications.

Module-II: Fire Alarm Detection System Requirement

Stages of Fire Alarm System, Component within Fire Alarm System, FAS Loops-Classification of Loops and Examples, Power Supply Requirement and its designing parameters

Module-III: Introduction to Smart building and Security Systems

Basic Concepts of Access Control System. Basic Component of Access Control System, Benefits of Access Control System. Cable Used in Access Control System and Its Terminology, Access Control System Devices features, Protocols for access Control system.

Module-IV: Access Security Systems: Basics of Access security systems, Types of Access Control stems, Access Control Systems Components such as Cameras, Lenses, Recording devices, storage and Network components and systems, Access control system design.

Module-V: HVAC Systems:

Introduction to HVAC Systems components, Introduction to the Psychrometric Chart, Basic Air-Conditioning System, Zoned Air-Conditioning Systems, System Choice Matrix, Human Comfort, Introduction to Thermal Comfort, Seven Factors Influencing Thermal Comfort, and Conditions for Comfort, Ventilation Process & Applications

Module-VI: HVAC& Air handling unit

Concept of Air handling unit. Design, working of different components in AHU damper, filter, cooling coil, heating coil, fan, heat recovery wheel, humidifier. Modes in AHU. Heating Process & Applications, Air Handlers and Unitary Equipment, Heaters, Boilers, Chillers, Cooling Towers. MCC Basics, Panel Components

References:

1. Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs) by Reinhold A. Carlson (Author), Robert A. Di Giandomenico (Author).
2. Fundamentals of HVAC Control Systems by Ross Montgomery, Robert McDowall Inc.1791 Tullie Circle NE, Atlanta, GA 30329, USA.
3. HVAC control System Design Diagrams, John I Levenhagen, Mc-Graw -Hill Publications.
4. HVAC Controls and Systems, I Levenhagen, Donald H Spethman McGraw-Hill Publications

PEC-562A-PRI: Industrial Safety

Teaching Scheme:	Credits:3	Examination Scheme:
TH : 3 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Define the key components and distinguish between Basic Process Control Systems (BPCS) and SIS.
2. Analyze risk using Layers of Protection Analysis (LOPA) and evaluate Safety Integrity Level (SIL) for process safety.
3. Interpret and apply international standards such as IEC 61508 and ANSI/ISA 84.01-1996.
4. Implement SIS design philosophy and conduct testing, maintenance, and validation of Safety Instrumented Systems.

Module-I: Introduction to Safety Instrumented Systems (SIS)

Definition, Need, and Importance of SIS in Process Industries, Difference Between Basic Process Control System (BPCS) and SIS, Key Components of SIS: Sensors, Logic Solvers, Final Control Elements, Role of SIS in Risk Reduction, Introduction to Functional Safety and Safety Instrumented Functions (SIF)

Module-II: Risk Assessment and Safety Integrity Level (SIL)

Understanding Risk and Hazard Analysis, Risk Measurement and Risk Tolerance Criteria, Layers of Protection Analysis (LOPA), Safety Integrity Level (SIL): Definition, Determination, and Assessment, SIL Verification and Validation Methods

Module-III: International Standards and Regulations: IEC 61508

Functional Safety of Electrical/Electronic/Programmable Systems, IEC 61511 (ANSI/ISA-84.00.01-2004): SIS in Process Industries, ANSI/ISA 84.01-1996: Process Safety Instrumentation, NFPA 85: Boiler and Combustion Safety Systems, API RP 556 & API RP 14C: SIS in Refining and Offshore Platforms, OSHA 29 CFR 1910.119: Process Safety Management (PSM) for Highly Hazardous Chemicals, Regulatory Compliance and Audit Requirements.

Module-IV: SIS Design and Implementation

Safety Lifecycle and SIS Design Philosophy, SIS Functional Requirements and System Architecture, Selection of Sensors, Logic Solvers, and Final Control Elements, SIS Redundancy, Reliability, and Availability Considerations, Fault Tolerance and Fail-Safe Design.

Module-V: SIS Testing, Maintenance, and Validation

Safety Instrumented System Testing: Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT), Proof Testing and Periodic Maintenance of SIS Components, Failure Modes, Effects, and Diagnostics Analysis (FMEDA), Common Cause Failures and Mitigation Strategies, SIS Performance Monitoring and Continuous Improvement.

Module-VI: Advanced in SIS

Cybersecurity Considerations for Safety Instrumented Systems (IEC 62443), Advanced Diagnostics and Predictive Maintenance for SIS, Smart Safety Systems and Industry 4.0 Integration, Case Studies: SIS Failures, Lessons Learned, and Best Practices, Future Trends in Functional Safety and SIS Technologies.

Reference

1. Paul Gruhn and Harry L. Cheddie," Safety Instrumented systems: Design, Analysis and Justification", ISA, 2nd edition, 2018.
2. Eric W. Scharpf, Heidi J. Hartmann, Harlod W. Thomas, "Practical SIL target selection: Risk analysis per the IEC 61511 safety Lifecycle", exida2nd Edition 2016.
3. William M. Goble and Harry Cheddie, "Safety Instrumented Systems Verification: Practical Probabilistic Calculations" ISA, 2005.
4. Edward Marszal, Eric W. Scharpf, "Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis", ISA, 2002.

5. Standard - ANSI/ISA-84.00.01-2004 Part 1 (IEC 61511-1 Mod) “Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Software Requirements”, ISA, 2004.
6. Safety Instrumented Systems Verification: Practical Probabilistic Calculation– William M. Goble, Iwan van Beurden.
7. Practical SIL Target Selection – Risk Analysis per the IEC 61511 Safety Lifecycle– David J. Smith.
8. The Safety Critical Systems Handbook: A Straightforward Guide to Functional Safety, IEC 61508 (2010 Edition) and Related Standards – David J. Smith, Kenneth G. L. Simpson.
9. Security PHA Review for Consequence-Based Cybersecurity-by Edward Marszal and James McGlon.
10. Quick Start Guide: An Overview of the ISA/IEC 62443 Standards- The ISA Global Cybersecurity Alliance (ISAGCA).

PEC-562B-PRI: Advanced Signal Processing

Teaching Scheme:	**Credits:3**	**Examination Scheme:**
TH : 3 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. List the basics of DFT and explain its application in linear transformation.
2. Describe the process of linear prediction using various methods such as auto-correlation, covariance, and lattice methods.
3. Identify different spectral estimation methods and compare their efficacy in practical applications.
4. Implement multirate DSP techniques including decimation, interpolation, and sampling rate conversion for efficient signal processing.

Module I: Discrete Fourier Transform and Its Applications: Basics of DFT, DFT as a Linear Transformation, Conversion of Linear Convolution to Circular Convolution, Linear filtering using overlap and add, overlap and save method, Frequency analysis of discrete signal: Speech Signal, ECG/EEG Signal, Introduction to Two Dimensional DFT, Application of Two – Dimensional DFT for Image Filtering.

Module II: Linear Prediction: Lattice structure realization, forward linear prediction, Auto correlation methods, Covariance Methods, lattice methods, Linear Spectral Frequencies: LPC to LSFs/LSPs Transformation, LSFs to LPC Transformation, Application of Linear Prediction.

Module III: Spectral Estimation: Estimation of Density Spectrum: Power and Energy Spectral Density, Nonparametric method, parametric methods, other estimation methods, Evaluation of cepstrum.

Module IV: Multirate DSP and Applications: Decimation and Interpolation, sampling rate conversion by I/D, Efficient Implementation of Interpolation and Decimation, Polyphaser Filter Structure, Multistage Filter Design, Sampling Rate Conversion of Band Pass Signals, Applications of Multirate DSP.

Module V: DCT, WT and Applications: Discrete Cosine Transform and Discrete Sine Transform, Applications of DCT, Short Time Fourier Transform, Wavelet Transform: Haar Wavelet and Multi resolution Analysis, Daubechies Wavelet, Some other standard Wavelets, Applications of WT.

Module VI: Adaptive filtering: Principles of Adaptive filtering, LMS and RMS Algorithms, Applications in noise and echo cancellation, Homomorphic Signal Processing, homomorphic system for convolution, properties of complex-spectrum, Applications of homomorphic deconvolution.

Reference Books:

1. Dr. S. D. Apte Advanced Digital Signal Processing, Wiley publications.
2. J. Proakis , Charles M. Rader, Fuyun Ling, Christopher L. Nikias, ‘Advanced Digital
3. Signal Processing’, (Macmillan CollDiv) (1992).
4. Glenn Zelniker, Fred J. Taylor, ‘Advanced Digital Signal Processing’, (CRC Press)
5. J. G. Proakis and D. G. Manolakis “Digital Signal Processing: Principles, Algorithms,
6. and Applications”, Prentice Hall of India Ltd, 1995.
7. C. S. Burrus, Ramesh and A. Gopinath, “Introduction to Wavelets and Wavelet Transform” Prentice Hall Inc.

PEC-562C-PRI: Artificial Intelligence and Machine Learning

Teaching Scheme:	**Credits:4**	**Examination Scheme:**
TH: 4 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

1. Define the key components and history of Artificial Intelligence and Machine Learning.
2. Analyze and implement problem-solving algorithms in AI applications.
3. Evaluate and compare different Machine Learning models for supervised and unsupervised learning tasks.
4. Create and develop AI systems for real-world applications using appropriate ML techniques.

Module I: Introduction to Artificial Intelligence: Introduction to Artificial Intelligence, Foundations of Artificial Intelligence, History of Artificial Intelligence, State of the Art, Risks and Benefits of AI, Intelligent Agents, Agents and Environments, Good Behavior: Concept of Rationality, Nature of Environments, Structure of Agents.

Module II: Problem solving using Artificial Intelligence: Solving Problems by Searching, Problem-Solving Agents, Example Problems, Search Algorithms, Uninformed Search Strategies, Informed (Heuristic) Search Strategies, Heuristic Functions, Search in Complex Environments, Local Search and Optimization Problems.

Module III: Planning: Automated Planning, Classical Planning, Algorithms for Classical Planning, Heuristics for Planning, Hierarchical Planning, Planning and Acting in Nondeterministic Domains, Time, Schedules, and Resources, Analysis of Planning Approaches, Limits of AI, Ethics of AI, Future of AI, AI Components, AI Architectures

Module IV: Introduction to Machine Learning: Introduction to Machine Learning, Comparison of Machine learning with traditional programming, ML vs AI vs Data Science. Types of learning: Supervised, Unsupervised, and semi-supervised, reinforcement learning techniques, Models of Machine learning: Geometric model, Probabilistic Models, Logical Models, Grouping and grading models, Parametric and non-parametric models. Important Elements of Machine Learning- Data formats, Learn ability, Statistical learning approaches

Module V: Supervised Learning: Regression: Bias, Variance, Generalization, Underfitting, Overfitting, Linear regression, Regression: Lasso regression, Ridge regression, Gradient descent algorithm. Evaluation Metrics: MAE, RMSE, R2

Classification: Classification: K-nearest neighbor, Support vector machine. Ensemble Learning: Bagging, Boosting, Random Forest, Adaboost. Binary-vs-Multiclass Classification, Balanced and Imbalanced Multiclass Classification Problems, Variants of Multiclass Classification: One-vs-One and One-vs-All Evaluation Metrics and Score: Accuracy, Precision, Recall, Fscore, Cross-validation, Micro Average Precision and Recall, Micro-Average F-score, Macro-Average Precision and Recall, Macro-Average F-score. #Exemplar/Case Studies P

Module VI: Unsupervised Learning: K-Means, K-medoids, Hierarchical, and Density-based Clustering, Spectral Clustering. Outlier analysis: introduction of isolation factor, local outlier factor. Evaluation metrics and score: elbow method, extrinsic and intrinsic methods.

Reference

1. Introduction to Machine Learning with Python by Andreas C. Müller, Sarah Guido
2. Machine Learning For Dummies by John Paul Mueller and Luca Massaron 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
3. Machine Learning For Absolute Beginners by Oliver Theobald
4. Python Machine Learning by Sebastian Raschka and Vahid Mirja lili
5. Understanding Machine Learning by Shai Shalev-Shwartz and Shai Ben-David
6. Nilsson Nils J , "Artificial Intelligence: A new Synthesis", Morgan Kaufmann Publishers Inc. San Francisco, CA, ISBN: 978-1-55-860467-4
7. Patrick Henry Winston, "Artificial Intelligence", Addison-Wesley Publishing Company,

ISBN: 0-201-53377-4
8. Andries P. Engelbrecht-Computational Intelligence: An Introduction, 2nd Edition-Wiley India- ISBN: 978-0-470-51250-0
9. Stuart Russell and Peter Norvig, “Artificial Intelligence: A Modern Approach”, Third edition, Pearson, 2003, ISBN :10: 0136042597
10. Deepak Khemani, “A First Course in Artificial Intelligence”, McGraw Hill Education(India), 2013, ISBN : 978-1-25-902998-1
11. Elaine Rich, Kevin Knight and Nair, “Artificial Intelligence”, TMH, ISBN-978-0-07-008770- 5

TS-571-PRI: Seminar - I		
Teaching Scheme: PR :4 Hrs./Week	**Credits:**2	**Examination Scheme:** Oral:25marks; TW:25marks

Course Outcomes:

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

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

Each student will select a topic in Instrumentation and Control Engineering preferably keeping track with recent technological trends and development beyond scope of syllabus avoiding repetition in consecutive years.

1. The topic must be selected in consultation with the institute guide.

2. Each student will make a seminar presentation using audio/visual aids for a duration

of 20-25 minutes and submit the seminar report in standard format.

The student shall submit the duly certified seminar report in standard format using LATEX, for satisfactory completion of the work by the concerned Guide and head of the department/institute.

Semester III

RM-631-PRI: Research Methodology

Teaching Scheme:	Credits:4	Examination Scheme:
TH: 4 Hrs./Week		Theory: 100marks (Insem: 50marks + Endsem: 50marks)

Course Outcomes

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

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

Module- I: Definition and Characteristics of Research

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

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

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

Module- II: Literature Search and Review

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

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

Module- III: Analysis of Variance and Covariance

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

Module- IV: Technical Writing and IPR

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

Module- V: Outcome of Research and Research Presentation

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

Research presentation: Introduction, Standard terms, Standard research methods and experimental techniques, Paper title and keywords, Writing an abstract, Paper presentation and review, Conference presentations, Poster presentations, IPR, Copyright, Patents.
Case Study: Intellectual Property India- services, InPASS - Indian Patent Advanced Search System, US patent, IEEE / ACM Paper templates.

Text Books:

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

References:

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

Practical Assignments:

Sr. No	Title	Objectives
1	Problem Identification Exercise	Identify and clearly define a real-world research problem
2	Literature Review Report	Conduct a detailed literature survey (minimum 30 research papers) and summarize gaps in existing research.
3	Research Proposal Drafting	Prepare a structured research proposal including problem statement, objectives, scope, and methodology.
4	Hypothesis Formulation	Develop testable hypotheses based on selected research
5	Design of Experiment	Design a detailed experimental plan or simulation for validating hypotheses.
6	Sampling Techniques	Select and justify a sampling method for data collection in your project.
7	Data Collection Tools Development	Design a survey questionnaire or sensor-based data collection method.
8	Statistical Data Analysis	Perform statistical analysis (ANOVA, regression, t-tests) on sample data.
9	Research Paper Writing	Draft a full research paper based on hypothetical or preliminary data.
10	Research Ethics and Plagiarism Check	Analyze ethical aspects and conduct a plagiarism check for your paper.

OJT-641-PRI: Internship/On Job Training

Teaching Scheme:	**Credits: 5**	**Examination Scheme:**
PR : 10 Hrs./Week		(TW: 100 marks)

Course Description:

- Internship/On Job Training provide students the opportunity of hands-on experience that includes personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.
- An internship is the phase of time for students when they are trained for their skills, they are good at, and it gives them a chance to apply their knowledge practically in industries
- The internship can be carried out in any industry/R&D Organization/Research Institute/Institute of national repute/R&D Centre of Parent Institute.
- Student may choose to undergo Internship/ on job training at industry/Govt./NGO/MSME/Rural Internship/Innovation/IPR/ Entrepreneurship. Student may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo internship/ on job training with industry/NGO's/Government organizations/Micro/Small/ Medium enterprises to make themselves ready for the industry.

The Department/college shall nominate a faculty to facilitate, guide and supervise students under internship.

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

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

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

Documentation and Reporting:

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

SEM-632-PRI: Seminar - II		
Teaching Scheme: PR :08 Hrs./Week	**Credits:**4	**Examination Scheme:** Oral:25 marks; TW:25marks

Course Outcomes:

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

Responsibility of the students:

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

Topic Selection

- Relevance: Topics must be directly related to Computer Engineering, encompassing current
research trends, emerging technologies, advanced concepts, or interdisciplinary applications.
- Scope: The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
- Novelty (Desired): While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
- Guide / Supervisor Approval: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.

Seminar Structure and Deliverables: The technical seminar typically involves the following stages and deliverables

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

Seminar Report/Paper (Due 2-3 weeks before presentation):

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

RP-642-PRI: Research Project-I		
Teaching Scheme: Practical: 18 Hrs./Week	**Credits: 9**	**Examination Scheme:** TW: 25marks; OR: 25 marks;

The master's degree culminates in a research project of the student's own design. This research project is documented by a final research report or dissertation. The student's work is guided by an academic supervisor. Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. Students are expected to construct a research project that includes original research, deliberate and well considered methodological choices, and shows relevance to significant conversations within the discipline. The dissertation should represent the very best research and analysis a student can produce.

Course Outcomes:

1. List key components of the problem statement and identify relevant literature sources to support the research project.
2. Demonstrate the ability to create a project overview, implement technical schemes, and develop various diagrams/models necessary for the research project.
3. Implement the layout and design of the research project setup effectively, showcasing specialized skills acquired during coursework.
4. Execute a well-structured presentation highlighting technological advancements related to the chosen dissertation topic.

Course Outcomes:

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

Guidelines

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

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

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

Semester-IV

SEM-671-PRI: Seminar on Project Stage-II		
Teaching Scheme: **Practical: 8Hrs./Week**	**Credits: 4**	**Examination Scheme:** TW: 50 marks; OR: 50 marks

Course Outcomes:

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

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

Guidelines

Responsibility of the students:

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

• Topic Selection

- Relevance: Topics must be directly related to Computer Engineering, encompassing current research trends, emerging technologies, advanced concepts, or interdisciplinary applications.
- Scope: The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
- Novelty (Desired): While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
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Seminar structure and deliverables: The technical seminar typically involves the following stages and deliverables

- Topic Proposal (2-3 weeks after topic approval):
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- Proposed Seminar Title
- Brief Description/Abstract of the Topic
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- Tentative Scope and Outline of the Presentation
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- Critical Analysis: Beyond mere summarization, students are expected to critically analyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
- Note-Taking & Organization: Maintain systematic notes and organize research material effectively.

• **Seminar Report/Paper (Due 2-3 weeks before presentation):**

- A written report (typically 15-25 pages, excluding references and appendices) detailing the seminar content.

- Format: Follow a professional academic paper format (e.g., IEEE transaction style).
- Sections:

  * Abstract: A concise summary of the seminar topic and key findings.

  * Introduction: Background, motivation, problem statement (if applicable), and outline of the report.

  * Literature Review/Background: Detailed discussion of relevant concepts, theories, and existing work.

  * Core Content: In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.

  * Analysis/Discussion: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.

  * Future Trends/Conclusion: Summarization of key takeaways, potential future directions, and concluding remarks.

  * References: A comprehensive list of all cited sources, properly formatted

  * Appendices (Optional): Supplementary material if necessary.

RP-681-PRI: Research Project Stage-II		
Teaching Scheme: **PR:36 Hrs./Week**	**Credits: 18**	**Examination Scheme:** TW: 150 marks; OR: 50 marks

Course Description:

The master's degree culminates in a research project of the student's own design. This project is documented by a final research report or dissertation. The student's work is guided by an supervisor or guide. Students are expected to construct a research project that includes original research, deliberate and well considered methodological choices, and shows relevance to significant conversations within the discipline. The dissertation should represent the very best research and analysis a student can produce. Study of relevant supplementary literature, mastering useful programming languages and tools for the problem, are also expected at this stage of the project.

Course Outcome

1. Implement the fabrication of required setup and work station for the research project.
2. Conduct experiments, collect data, and interpret results accurately.
3. Analyze and validate the research findings using appropriate statistical methods.
4. Generate a well-structured final report documenting the project work and outcomes effectively.

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

General Guidelines

- Student shall consolidate and complete the remaining part of the research work started in Semester III. This will consist of Selection of Technology, Installations, implementations, testing, Results, measuring performance, discussions using data tables per parameter considered for the improvement with existing/known algorithms/systems, comparative analysis, validation of results and conclusions.
- Student shall prepare the duly certified final report of dissertation in standard format for satisfactory completion of the work by the concerned guide and head of the Department/ Institute.
- Students are expected to validate their study undertaken by publishing it at standard platforms.
- The investigations and findings need to be validated appropriately at standard platforms like conference and/or peer reviewed journal.
- Student has to exhibit continuous progress through regular reporting and presentations and proper documentation of the frequency of the activities in the sole discretion of the PG coordination/Head of the department. The continuous assessment of the progress needs to be documented unambiguously.
- Supervisor Interaction: Minimum one meeting per week.
- Logbook: Maintain a record of work progress and supervisor comments.

- Ethics: No plagiarism, false results, or unethical practices allowed.
- Backup: Keep source code, datasets, and reports backed up securely.
- Submission Format: Soft copy (PDF) + Hard copy as per institute norms.

• **Key Components:**

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

ME – Instrumentation and Control (Process Instrumentation) (2025Pattern)	
Task Force for Curriculum Design and Development	
Team Members for Course Design	
Course Coordinator	
Dr. P. S. Vikhe	
Team Members for Course Design	
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Mr. N. N. Lokhande	Dr. V. S. Rane
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