Cummins College of Engineering for Women

(An autonomous institute affiliated to Savitribai Phule Pune University)

Karve Nagar, Pune - 411 052.

Vision

To be globally renowned engineering institute for imparting holistic education and developing professional women leaders in engineering and technology

Structure and Syllabus

of

T. Y. BTech

(Instrumentation and Control Engineering)

2023 Pattern [R0]

List of Abbreviations

Abbreviation	Title
PC	Programme Core Course
BSC	Basic Science Course
ESC	Engineering Science Course
PE	Programme Elective Course
OE	Open Elective
VSEC	Vocational and Skill Enhancement Course
CC	Co-curricular Courses / Liberal Learning Course
IKS	Indian Knowledge System
VEC	Value Education Course
RM	Research Methodology
INTR	Internship
PROJ	Project
CEP	Community Engagement Project
Mm	Multidisciplinary Minor
AEC	Ability Enhancement course

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Curriculum for UG Degree Course in BTech. Instrumentation and Control Engineering
(Academic Year: 2025-26 Onwards)
Third Year | Semester-VI

Sr. No.	Course Code	Course Title	Teaching Scheme (Hours/week)			Credits	Examination Scheme			Total Marks
			L	T	P		ISE	ESE	Pr/Or	
1	23PCIN601	Industrial Automation	3	0	0	3	50	50	0	100
2	23PCIN602	System Engineering and Management	3	0	0	3	50	50	0	100
3	23PCIN603	Process Data Analytics	3	0	0	3	50	50	0	100
4	23PCIN604	Process Instrumentation and Control	3	0	0	3	50	50	0	100
5	23PEIN601	Programme Elective Course-II	3	0	0	3	50	50	0	100
6	23MmIN601	Energy Management and Audit	2	0	0	2	25	25	0	50
7	23VSEC601	Data Structures	0	0	4	2	50	0	0	50
8	23PCIN601L	Industrial Automation Lab	0	0	2	1	25	0	25	50
9	23PCIN602L	System Engineering and Management Lab	0	0	2	1	25	0	25	50
10	23PCIN603L	Process Data Analytics Lab	0	0	2	1	25	0	25	50
Total =			**17**	**0**	**10**	**22**	**400**	**275**	**75**	**750**

L=Lecture, T=Tutorial, P= Practical, Cr= Credits, ISE =In Semester Evaluation, ESE =End Semester Examination, Pr/Or = Practical/Oral

23PEIN601: Programme Elective-II

A. Instrumentation in EV
B. Building Automation
C. Micro Electro Mechanical Systems
D. Safety in Automation

Instrumentation and Control Department

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Secretary Academic Council
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Chairman Academic Council
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23PCIN601 Industrial Automation

Teaching Scheme
Lecture : 3 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 3

Prerequisites: Basics of Process Loop Components

Course Objectives:
1. Understand the basic concepts of automation and its requirements.
2. To develop an automation project and its documentation.
3. To learn and apply standards and recommended practices to automation.
4. To understand the activities followed in automation projects

Course Outcomes: The student will be able to,
1. Explain the working principles of automation tools and industrial communication protocols.
2. Write PLC/DCS logic for specified field applications.
3. Prepare wiring diagrams to interface field devices to PLC/DCS systems.
4. Design a complete automation and safety solution as per relevant safety standards for a given application.

Unit I: Introduction to Industrial Automation & Programmable Logic Controllers (PLC) Basics
Overview of Industrial Automation: Purpose, scope, and trends, Continuous versus Discrete Process Control, Limitations of relay based system,
PLC architecture, Types of Input & Output modules, Fixed & Modular PLC, PLC specifications, PLC manufacturers, Comparison of automation tools PLC, HMI, SCADA, DCS, IEC 61131-3 standard overview, Introduction to Ladder Programming: basic logic gates, Timers, Counters, Program Control Instructions

Unit II: PLC Advanced Programming and Interfacing with Field Devices
PLC Advanced Programming: Data Manipulation Instructions, Sequencer and Shift Register Instructions, Analog control loop (PID) configuration in PLC,
Interfacing with field devices: sourcing/sinking concept, interfacing of discrete devices, analog devices, Special components like encoders, load cells, Actuators.

Unit III: Industrial Communication Protocols
Communication standards, Modbus (ASCII/RTU), Foundation fieldbus (H1/HSE), Profibus, Profinet, Industrial Ethernet, CAN, DeviceNet, ControlNet and HART protocols, Introduction to third party interface, Comparison between the protocols, PLC to HMI/SCADA interfacing

Unit IV: Distributed Control System: Hardware

DCS introduction, Architecture of different makes: comparison and specification, DCS System Layout, Loop wiring, Redundancy, I/O Card Details, Junction Boxes and Marshalling Cabinets, System cabinet, Operator Interface, DCS Workstation and their Types

Unit V: Distributed Control System Programming

DCS Programming, Configuration of discrete and analog IO's and programming, Database management, Device Signal Tags, Faceplate Configuration, Historical data using in log, Report and Trend display, Types of alarm, Alarm management.

Unit VI: Process Safety and Safety Management System

Introduction to process safety, process hazard analysis, safety integrity levels (SIL), Introduction to IEC61511 standard, SIS application for safety system.

Text Books:

1. Frank D. Petruzella, "Programmable Logic Controllers"
2. S.K.Singh, "Computer Aided Process Control", PHI.
3. Krishna Kant, "Computer Based Process Control", PHI.
4. Frank Lamb, "Industrial Automation Hands On", Mc Graw Hill.
5. Popovic and Bhatkar , Distributed Computer Control For Industrial Automation, Taylor & Francis group, 2011.

Reference Books:

1. Samuel Herb, "Understanding Distributed Process Systems for Control", ISA.
2. Webb & Reis, "Programmable Logic Controllers: Principles and Applications", PHI
3. Gary Dunning, "Introduction to Programmable Logic Controller", Cengage Learning India Pvt. Ltd., Third ed., 2006.
4. B. G. Liptak, "Process Control", Instrument Engineering Handbook CRC Press.

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23PCIN602 System Engineering and Management

Teaching Scheme
Lecture: 3 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 3

Pre-requisites: Process Loop Components

Course Objectives:
1. To know the concepts of project engineering and management as applied to instrumentation projects.
2. To develop a comprehensive understanding of engineering design documentation, drawings, and specifications as per industrial practices.
3. To provide the knowledge of relevant national and international standards for system engineering.
4. To understand different project stages like contracting, procurement, installation and commissioning

Course Outcomes: By the end of the course, students should be able to
1. Prepare project planning and scheduling documents for instrumentation projects using appropriate tools and techniques
2. Apply national and international standards and recommended practices for interpreting project engineering design documents
3. Analyse instrumentation project engineering design documents
4. Prepare testing and commissioning documentation

Unit I: Basic Concepts of Project Management
Definition, Types and Life cycle phases of project, Basics of Project management, Project Planning, Scheduling, Tools and techniques of project management.

Unit II: Instrumentation Documentation and its Related Standards
Detailed discussion of ISA standards, FEED documents (PFD, Material balance, P&ID etc.) and DED documents (Process data sheets, instrument index, instrument specification sheet, calculation sheets like valve sizing, thermowell design, orifice design etc.).

Unit III: Panels and Wiring Documentation
Electrical Panels: Specification, GA drawings, Instrumentation Panels (Instrument panels, Marshalling panels) Terminal Strip reports, Power requirement calculation etc. Instrument Cable: Types, specification, Cable trays, Control room engineering.

Unit IV: EPC Contracting and Procurement Activities
Introduction to EPC contracting, Vendor registration, requirements for qualification documents. Tendering and bidding process, requirement and qualification documents, Bid

evaluation (Role and knowledge required as an instrumentation engineer), Purchase orders etc..

Unit V: Installation

Understand, design and develop instrument Installation sketches for various instruments (Hook up drawings like Thermowell, Flow transmitter, Differential pressure transmitter, orifice, pitot tube, rotameter, DPT type level transmitter installation specification etc.

Unit VI: Commissioning and testing

Inspection and Testing: Factory Acceptance Test (FAT) Team, Planning, documentation, Customer or Site Acceptance Test (CAT or SAT), Team, Planning, documentation. Test and inspection reports. Pre-commissioning planning activities, documents required for Cold Commissioning and hot commissioning, Performance trials and final hand over, Calibration records

Text Books:

1. Applied instrumentation in process industries by Andrew & Williams (Gulf Publishing)
2. Management Systems by John Bacon (ISA)
3. Process control Instrument Engineers Handbook by Liptak.

Reference Books:

1. Instrument Installation Project Management (ISA).
2. Successful Instrumentation & Control Systems Design, by Michael D. Whitt (ISA)

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23PCIN603 Process Data Analytics

Teaching Scheme:
Lecture: 3 Hrs/week

Examination Scheme:
In semester: 50 Marks
End semester: 50 Marks
Credits: 3

Prerequisite Courses: Applied Mathematics: Transforms and Statistics, Data Science in Sustainability

Course Objectives:
1. To equip students with data analysis techniques relevant to process industries.
2. To develop skills in industrial data handling
3. To introduce machine learning techniques for process industry applications.

Course Outcomes: Students will be able to
1. Explain fundamental concepts, roles, types and applications of data analytics in industrial systems.
2. Apply statistical methods to monitor process performance.
3. Analyze the given datasets using machine learning methods.
4. Explore industrial analytics processes to identify potential safety risks, ethical issues, data privacy concerns, and security vulnerabilities in compliance with relevant standards.

Unit I: Introduction to Data Analytics
Need and scope of data analytics in process industry, Process Data lifecycle, Importance of data analytics in safety, efficiency, and quality improvement, **Nature of process industry data:** continuous, batch, hybrid processes, **Industrial data sources:** DCS, PLC, SCADA, MES, ERP, LIMS, IoT **Data types:** SQL and No-SQL data and their properties
Types of data analytics: Descriptive, Diagnostic, Preventative and Prescriptive, Application of each type of analytics in various process and manufacturing industries.

Unit II: Inferential Statistics
Introduction to Hypothesis Testing: Null and Alternative Hypotheses, Types of Errors: Type I and Type II, Significance Levels, types of hypothesis testing, Confidence Intervals: Definition and Interpretation, Relationship between confidence intervals and hypothesis testing

Unit III: Capability Analysis in Statistical Process Control
Statistical Process Control (SPC) fundamentals, Control charts: X-bar, R, p-chart, np, c & u charts, CUSUM & EWMA charts, Control vs. specification limits, Short-term vs. long-term capability, Process capability analysis (Cp, Cpk), Case Study

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Unit IV: Supervised Learning Methods
Introduction to supervised learning.
Regression Methods and Metrics: Linear regression, Logistic regression , Regression Metrics
Classification Methods and Metrics: Decision trees, Random forests, Support vector machines (SVM), k-nearest neighbors (k-NN), Naïve Bayes classification, Classification Metrics. Case studies and industrial applications.

Unit V: Unsupervised Learning Methods
Introduction to unsupervised learning and its role in industrial analytics.
Clustering Methods and Metrics: k-means clustering, Hierarchical clustering, Cluster Evaluation Metrics, Overfitting and Underfitting strategies.
Association Rule Mining: Apriori algorithm, Eclat algorithm,
Case studies and industrial applications.

Unit VI: Data Ethics and Security in Industrial Analytics
Data Ethics Principles: Fairness, accountability, transparency, and avoidance of bias in industrial analytics.
Privacy Regulations & Compliance: General Data Protection Regulation (GDPR), California Consumer Privacy Act (CCPA), industry-specific standards ISO/IEC 27001
Data Security Fundamentals: Threats, encryption, secure protocols, secure storage and transfer. Case Studies

Books:
1. EMC Education Services, “Data Science & Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data”, Print ISBN:9781118876138, 2015 by John Wiley and Sons.
2. S. Sridhar and M. Vijayalakshmi, “Machine Learning”, First Edition, ISBN: 9780190127275, 2021 by Oxford University Press.
3. Gypsy Nandi and Rupam Sharma, “Data Science Fundamentals and Practical Approaches”, First Edition 2020, ISBN: 9789389845662 by BPB Publications, India.
4. Joel Grus, “Data Science from Scratch: First Principles with Python”, Second Edition, ISBN: 9789352138326, 2019 by O’Reilly Publications.
5. Vinod Chandra and Anand Hareendran, “Machine Learning A Practitioner’s Approach”, ISBN: 9789389347463, 2022 by PHI Learning Private Limited, Delhi.

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23PCIN604 Process Instrumentation and Control

Teaching Scheme
Lecture: 3 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 03

Prerequisites: Sensors and Transducers, Process Loop Components

Course Objectives:
1. To delineate the principles of multi-loop controllers and nonlinear systems
2. To design the multivariable control systems for interacting processes
3. To develop and analyse the control loops for various process applications

Course outcomes: The students will be able
1. To identify the characteristics of the given process
2. To compare the features of different control strategies
3. To select an appropriate control strategy for a given application
4. To develop the instrumentation and control loops for various processes

Unit I: Multi-Loop Control
Introduction to Unit Operations.Various control strategies used in process control like: Feedback, feed forward control, cascade control, ratio control, selective control, split-range control and their applications

Unit II: Heat exchanger Controls
Types, gain and time constants, degrees of freedom. Basic controls in Heat exchangers, Steam Heaters, Condensers, fired heaters and vaporizers. Advanced Controls: Override, Feed forward Control.

Unit III: Boiler Controls
Types, Components, Boiler controls like Drum level control (1,2,3 element), Combustion controls, Air-fuel ratio control, Steam temperature and pressure control, Safety interlocks, Burner management system, start-up and shutdown procedures, boiler safety standards, Boiler Optimization

Unit IV: Distillation Column Control
Mass and Energy balance, column feed control, column pressure control, control of overhead and bottom composition, distillate reflux flow control. Frequency response, lag in liquid and vapour flow, concentration lag, predicting the behaviour of control system

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Unit V: Reactor and Pumps and Compressor Control

Types of reactions and reactors, factors governing the conduct of reaction, stability of reactors, time constant, effects of lag, flow control, temperature control, pH control, end point detection of continuous and batch reactors. Sequential & logic control in batch process, batch production management.

Pumps: Types, Basic Controls, Compressors: Types, Basic Controls.

Text Books:

1. Process Control Systems: F.G. Shinskey, TMH.
2. Instrument Engineers' Handbook: Process Control: B.G. Liptak, Chilton.
3. Optimization of Industrial Unit Processes - Bela G. Liptak

Reference Books:

1. Boiler Control Systems: David Lindsey, Mc GRAW-HILL
2. Process Dynamics and Control: Seborg, Wiley
3. Chemical Process Control: George Stephonopolous
4. Process Control: Thomas Marlin, Mc GRAW-HILL

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23PEIN601A Instrumentation for Electric Vehicles

Teaching Scheme
Lecture: 3 Hrs/week

Examination Scheme
In semester: 50 Marks
End semester: 50 Marks
Credits: 2

Prerequisite: Sensors and Transducers, Analog and Digital Electronics, IoT

Course Objectives:
1. Introduce students to the fundamental principles of electric vehicle (EV) systems and the role of instrumentation in monitoring, control, and safety.
2. Develop knowledge of various sensors, measurement techniques, and data acquisition systems specific to EV components such as batteries, motors, power electronics, and charging infrastructure.
3. Equip students with the skills to analyze, design, and implement instrumentation systems for optimizing performance, detecting faults, and managing energy in electric vehicles.
4. Foster awareness of emerging technologies, industry standards, and sustainability considerations in EV instrumentation for future innovation and research.

Course Outcomes: The students will be able to
1. Explain the components and working of Electric Vehicle systems.
2. Select sensing systems for various parameters of electric Vehicles.
3. Apply different methods for fault diagnosis and performance improvement.
4. Design suitable solutions in Electric Vehicle systems.

Unit I: Fundamentals of Electric Vehicles and Instrumentation Basics
Overview of electric vehicle architectures: battery electric, hybrid, and fuel cell EVs, EV powertrain components and their instrumentation needs, Safety standards and regulations for EV instrumentation, Vehicle chassis and basic structure of electric vehicles

Unit II: Sensors and Measurement Techniques in EVs
Sensors for electrical parameters: voltage, current, power, energy, Temperature sensing for batteries, motors, and electronics, Speed, torque, and position measurement for electric motors
Battery State-of-Charge (SoC) and State-of-Health (SoH) estimation methods
Charging infrastructure instrumentation: AC/DC charging, smart metering
Case studies of sensor selection in EV subsystems

Unit III: Data Acquisition and Communication protocols
Embedded systems and controllers for EV instrumentation, CAN, LIN, and other communication protocols in EVs, Real-time data logging and monitoring systems, Vehicle

instrumentation systems - battery monitoring, safety systems, tire pressure monitoring, e-call systems. infotainment.

Unit IV: Fault Diagnosis and Performance Optimization
Diagnostic tools and onboard fault detection algorithms, Vibration, thermal, and electrical stress monitoring, Vehicle test bench instrumentation. Introduction to predictive maintenance for EV components, Optimization of battery usage and thermal management systems, Trends in EV instrumentation: IoT integration, AI-based diagnostics

Unit V: Energy Management and Sustainability
Regenerative braking monitoring and control, Energy flow measurement and efficiency analysis in EVs, Instrumentation for fleet monitoring and telematics, Sustainability considerations and industry best practices in EV design, Case studies

Text Books:
1. 'Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design' by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi - CRC Press
2. 'Electric and Hybrid Vehicles: Design Fundamentals' by Iqbal Husain - CRC Press
3. 'Automotive Sensors and Instrumentation' by John Turner - SAE International
4. 'Electric Vehicle Systems Architecture and Performance' by Chris Mi, M. Abul Masrur, David Wenzhong Gao - Wiley

Reference Books:
1. 'Electric Vehicle Technology Explained' by James Larminie, John Lowry - Wiley
2. 'Automotive Instrumentation and Vehicle Electronics' by R. P. Sharma - Dhanpat Rai & Co.
3. 'Automotive Mechatronics: Operational and Practical Issues' by Konrad Reif (Ed.) - Springer

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23PEIN601B Building Automation Systems

Teaching Scheme:
Lecture: 3 Hrs/week

Examination Scheme:
In semester: 50 Marks
End semester: 50 Marks
Credits: 3

Prerequisites: Basics of Electronics and Instrumentation

Course Objectives:
1. Enable students to understand basic concept of building automation
2.Learn to create safe, secure, comfortable, healthy, and sustainable environment in buildings
3.Learn to bring energy efficiency in building systems

Course Outcomes: The student will be able to
1. Explain concepts and key features of Building Automation Systems.
2. Comprehend various components of Building Automation Systems.
3. Select suitable BAS subsystems and components for various buildings.
4. Evaluate the performance of Building Automation Systems.

Unit I: Introduction to BAS

Evolution of intelligent, green, and smart buildings, BAS architecture.
Key subsystems: HVAC, Fire, Security, Lighting, etc. all integrated.
Communication protocols: BACnet, KNX, IoT-enabled BAS.

Unit II: Comfort & Sensing Technologies for BAS

Comfort factors: Temperature, Humidity, Airflow, & Indoor Air Quality.
Sensors: Sensors for various Indoor Air Quality parameters, BTU meters.
Psychrometric Chart. Air Filters.

Unit III: HVAC Water Systems

Chilled Water: Refrigeration cycle, chillers, cooling towers, heat pumps.
Hot Water: Boilers, heat exchangers, geothermal, solar water heaters.
Efficiency: VFDs, smart pumping, AI-driven water load balancing.

Unit IV: HVAC Air Systems

Air Handling Units(AHU): Components and Working modes (cooling, heating, dehumidification, economizer). AHU Variants: 100% Outdoor Air, Mixed Air, Constant Air Volume, Variable Air Volume (VAV), Dual/Single Duct. Heat recovery: Plate exchangers, heat wheels, glycol systems. Smart Control: Zonal VAV, demand-based ventilation, critical-area (hospital/lab) needs. AI-enabled air distribution systems.

Unit V: Fire Detection and Alarm Systems

Fire fundamentals & Codes: NFPA 72, IS 2189, BS 5839.

Fire Alarm Types: Conventional, Addressable, Networked and IoT Enabled. Components: Initiating Devices, Notification Appliances, panels. Wiring Standards and loops. Power Supply and Batteries Design. Advanced: VESDA, IoT-enabled fire safety integration.

Unit VI: Building Security: Access Control & CCTV

Access Control: Smartcards, biometrics, mobile authentication.

Features: Anti-passback, Guard Tour, Time & Attendance.

CCTV: Analog, IP, PTZ Cameras, IOT enabled Cameras, AI - IOT enabled video analytics. Digital Video Management: Digital Video Recorder/Network Video Recorder, Cloud-based Video Recorder.

Text Books:

1. Building Automation: Control Devices and Applications – Cengage Learning.
2. Sinha, S., & Ghosh, A. (2019). Building Automation: Control Devices and Applications. Delmar Cengage Learning.
3. Hordeski, M. F. (2005). Smart Buildings: Advanced Materials and Nanotechnology to Improve Energy Efficiency and Environmental Performance. The Fairmont Press.
4. McDowall, R. S. (2008). Fundamentals of HVAC Systems. Elsevier / ASHRAE Learning Institute.
5. Boyd, A. (2017). Fire Alarm Systems: A Reference Manual. BSI / Fire Protection Association.
6. Garcia, M. L. (2020). The Design and Evaluation of Physical Protection Systems (3rd ed.). Butterworth-Heinemann.
7. Burke, R. J. (2016). Introduction to Security Systems (9th Ed.). Butterworth-Heinemann.

Reference Books:

1. KNX Association. KNX Basics and System Specifications.
2. BACnet International. BACnet: The Global Standard for Building Automation and Control Networks.
3. Sauter, T., Lobashov, M. (2011). End-to-End Communication Architecture for Smart Buildings. IEEE Transactions on Industrial Electronics.
4. ASHRAE Handbook Series (Fundamentals, HVAC Systems and Equipment).
5. NFPA 72 – National Fire Alarm and Signaling Code (Latest Edition).
6. Fire Alarm Systems: A Reference Manual – Canadian Fire Alarm Association
7. Kruegle, H. (2011). CCTV Surveillance: Video Practices and Technology (2nd Ed.). Butterworth-Heinemann.
8. Poyner, B. (2003). Designing for Effective CCTV and Building Security. Perpetuity Press.
9. Kratzer, C. (2014). Access Control and Identity Management. CRC Press.
10. Cisco Press. (2018). Cisco Video Surveillance IP Camera and Network Design Guide.
11. Pelco / Axis / Honeywell Technical Manuals (Latest Editions).

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23PEIN601C Micro Electro Mechanical Systems

Teaching Scheme
Lecture: 03 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 03

Course Objectives:
1. To introduce emerging MEMS field and importance of micro scaling to students
2. To provide knowledge of advanced materials, sensors and actuators
3. To learn advance micro fabrication techniques
4. To know advancement in instrumentation field of bio, automotive, aerospace field

Course outcomes: The students will be able
1. Explain the concepts of MEMS, smart materials, and microsystems.
2.Compare to Select appropriate micro sensor, micro actuator for given application.
3.Apply microfabrication and interfacing techniques in MEMS design
4.Design MEMS based solution for given application.

Unit I: Introduction to MEMS

Miniaturization, Microsystems Versus MEMS, Why Microfabrication, Smart Materials, Structures and Systems, Integrated Microsystems, Micromechanical Structures, Microsensors and Microactuators applications

Unit II: Smart Material

Shape memory Materials, Electrostrictive Materials, Magnetostrictive Materials, Rheological Materials, Electro chromic Materials, Self-healing Material, Conducting polymer, carbon nanotubes

Unit III: Micro Sensor

Micro sensor - Silicon Capacitive Accelerometer, Piezoresistive Pressure Sensor, Conductometric Gas Sensor, Fibre-Optic Sensors, Electrostatic Comb-Drive, Design of MEMS sensor.

Unit IV: Micro Actuator

Micro Actuator - Magnetic Micro relay, Microsystems at Radio Frequencies, Piezoelectric Inkjet Print Head, Portable Blood Analyzer, Micro mirror Array for Video Projection, Micro-PCR Systems, Microfluidics

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Unit V: Micro Fabrication

Silicon as a Material for Micromachining, Crystal Structure of Silicon, Silicon Wafer Preparation, Thin-film Deposition, Lithography, Doping the Silicon Wafer: Diffusion and Ion Implantation of Dopants, Etching, Dry Etching, Silicon Micromachining,Wafer Bonding & Packaging of MEMS

Unit VI: MEMS –Electronics and Applications

Basic electronics design, Interface Electronics for MEMS, applications/product development based on MEMS sensor. Mathematical modeling of sensors using suitable software. MEMS sensors for environmental monitoring for sustainability

Text Books:

1. Micro And Smart Systems by G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Atre : Wiley, India (2010).
2. Microfluidics and Microfabrication by Suman Chakraborty
3. Foundation of MEMS by Chang Liu
4. An Introduction to MEMS by Nadim Maluf and Kirt Williams

Reference Books:

1. Smart Material Systems and MEMS: Design and Development Methodologies, Vijay, K., Varadan K., Vinoy J. Gopalakrisham S. Willey 2006
2. Smart materials and new technologies, Addington, M. ,Schodek, Daniel L. Architectural Press, 2005.
3. Smart Structure and Materials, Brain Culshaw Artech House – Borton. London 1996
4. Smart Structure analysis and design, Srinivasan A.V., Michael McFarland D., Cambridge University Press, 2001
5. Fundamentals of Micro fabrication, Marc Madou

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23PEIN601D Safety in Automation

Teaching Scheme
Lecture: 3 Hrs/week

Examination Scheme
In semester: 50 marks
End semester: 50 marks
Credits: 03

Course Objectives:
1. Understand the fundamentals and importance of safety in industrial automation systems.
2. Explain relevant international and national safety standards and legislation.
3. Identify hazards and perform systematic risk assessments in automated environments.

Course outcomes: The students will be able to
1. Explain the risk analysis and estimate the performance level of a machine
2. Apply safety norms and standards in safety solutions for Automation systems
3. Analyze the effectiveness of guarding methods, electrical safety devices, and risk reduction strategies
4. Prepare safety compliance documentation to meet regulatory requirements.

Unit I: Introduction to Safety in Automation
Definition of safety, Importance of plant/machine safety, Cost of accidents, Primary and secondary causes of accidents, Benefits of proactive safety: cost saving, accident prevention, employee morale

Unit II: Safety Legislations and Standards
Overview of international and national safety legislation,
1. USA, Europe (EN), India
2. ISO, UL, CE marking

Machine safety standards and regulations, Equipment safety directives and machinery regulation compliance

Unit III: Risk Assessment in Automation Systems
Systematic approach to hazard identification, Risk evaluation and estimation,
Severity vs. probability matrix, Determining scope and scale of safety systems required,
Risk reduction hierarchy

Unit IV: Safety Components and Subsystems
Mechanical guarding:
Fixed, movable, adjustable, interlocking (with guard locking)
Electrical safety:
Safety distance, light curtains, two-hand control, safety scanners, safety trips
Safety circuits and control functions
Pneumatic and hydraulic system safety:

Component requirements
System design for risk reduction

Unit V: Functional Safety and Compliance

Functional safety of control systems:
Awareness of ISO 13849, IEC 62061, etc.
Performance Level (PL) and Safety Integrity Level (SIL)
Safety validation and assessment process
Compliance documentation:
Operating manuals
Safety reports
Legal and procedural records

Text Books:

1. R.K. Jain, Industrial Safety, Health and Environment Management Systems, Khanna Publishers.
2. Dilip Kumar, Industrial Safety, Health and Environment, S. Chand Publishing.
3. K. Uday Kumar Reddy, Industrial Safety, Notion Press. S.R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGraw-Hill Education.
4. Andrew Parr, Hydraulics and Pneumatics: A Technician's and Engineer's Guide, Butterworth-Heinemann (Elsevier).
5. K. S. Venkat Subramaniam, Industrial Safety Management, Himalaya Publishing House.

Reference Books:

1. David Macdonald, Practical Machinery Safety, Newnes (Elsevier).
2. David Macdonald, Practical Industrial Safety, Risk Assessment and Shutdown Systems, Newnes (Elsevier).
3. David J. Smith and Kenneth G. L. Simpson, Functional Safety: IEC 61508 and Related Standards, Elsevier.
4. Béla G. Lipták, Instrument Engineers' Handbook: Safety and Reliability, CRC Press.
5. Roland W. Schmitt, Safety of Machinery: Directive and Standards – A Handbook, Springer.

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23MmIN601 Energy Management and Audit

Teaching Scheme
Lecture: 2 Hrs/week

Examination Scheme
In semester: 25 Marks
End semester: 25 Marks
Credits: 2

Prerequisites: -

Course Objectives:
1. Gain a comprehensive understanding of the principles and practices of energy management, including energy conservation, efficiency, and sustainability.
2. Develop skills to analyze and evaluate various energy systems and industrial processes.
3. Acquire knowledge on methods to implement and manage energy efficiency measures and technologies to reduce energy consumption and operational costs.
4. Understand the process to prepare detailed technical reports and documentation based on audit findings, including recommendations for energy savings and system improvements.
5. Learn the process of how to perform systematic energy audits to assess energy usage, identify inefficiencies and recommend improvements.

Course Outcomes: the students will be able to
1. Explain the core principles of energy management and the key steps involved in the energy audit process.
2. Apply various energy measurement techniques and energy management strategies to enhance energy efficiency for the given facility.
3. Prepare a standard energy audit document for the given application.
4. Explore the impact of emerging trends in energy management systems.

Unit I: Introduction
Definition and objectives, Energy scenario in India and globally, Energy Standards, Energy policy and energy planning
Energy Audit: Need, Fundamentals, Types, Methodology and procedures, Benchmarking and performance analysis

Unit II: Energy measurement and analysis
Energy measuring instruments, Energy accounting and energy balance, Energy Cost and Efficiency, Load profiling and demand analysis, Power factor improvement techniques

Unit III: Energy Management strategies
Techniques for improving Energy Efficiency, Efficient HVAC, Energy Management Systems (EnMS), Energy Conservation Measures(ECMs) in electrical systems-Lighting, motors, transformers, etc

ECMs in thermal systems-Boilers, furnaces, steam systems
Waste heat recovery techniques, Renewable energy integration

Unit IV: Emerging trends and technologies
Predictive maintenance, smart metering, Microgrids and peer-to-peer energy trading, Future Energy Trends, Case studies and real world examples

Text Books:
1. "Energy Management Handbook" by Wayne C. Turner and Steve Doty 9th Edition - River Publishers
2. "Energy Efficiency and Management for Engineers" by Mehmet Kanoglu and Yunus Cengel 1st Edition McGraw-Hill Education

Reference Books:
1. "Energy Management and Conservation Handbook" by D. Yogi Goswami, Frank Kreith, and John C. G. St. Clair 2nd Edition, CRC Press
2. Guide to Energy Management, by Barney L. Capehart, William J. Kennedy and Wayne C. Turner 8th Edition - River Publishers

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23VSEC601 Data Structures

Teaching Scheme
Practical: 4 Hrs/week

Examination Scheme
In semester: 50 Marks
Credits: 2

Course Outcomes: the students will be able to
1. Solve the given computational problem by using the appropriate data structures
2. Compare to select appropriate searching and sorting algorithms for the given datasets
3. Apply appropriate data structures to implement solutions for given computational problems
4. Design data structure based solutions for real world applications

List of Practical Assignments(minimum 11):
Group A: (at least any 7)
1. Implement Array as Abstract data type(insertion, deletion, and resizing.)
2.Write code to perform operations such as searching, sorting, and merging of arrays.
3. Implement Stack as Abstract data type (operations like push, pop and peek).
4. Develop a stack using an array and a linked list.
5. Implement Queue as Abstract data type (enqueue, dequeue and front operations).
6. Create a queue using an array and a linked list.
7. Develop a circular queue to demonstrate efficient space utilization.
8. Implement singly linked lists and doubly linked lists with operations such as insertion, deletion, and traversal.
9. Binary Search Tree - Implement a binary search tree with insertion, deletion, and search operations.
10. Binary Search Tree - Write functions for in-order, pre-order, and post-order traversal.
Group B:
11. Implement and analyze various sorting algorithms like Bubble Sort, Merge Sort, Quick Sort, Heap Sort.
12. Implement linear search and binary search algorithms. Compare the performance of linear search and binary search algorithms on sorted and unsorted datasets.
Group C: (any 2)
13. Develop a simple text editor that supports operations like undo, redo, search, and replace using appropriate data structures.
14. Create a scheduling system for tasks or processes using a priority queue or heap to manage task priorities and execution order.
15. Develop a solution for inventory management systems by applying appropriate data structures.

Or similar types of practical assignments based on the course contents**.**

23PCIN601L Industrial Automation Lab

Teaching Scheme:
Practical: 2 Hrs/week

Examination Scheme:
In semester: 25 marks
Practical: 25 marks
Credits: 1

Prerequisites: Basics of control system components, Basics of Process Instrumentation

Course Outcomes: By the end of the course, students should be able to
1. Configure PLC and DCS systems for specified industrial applications.
2. Develop PLC and DCS programs using basic, advanced control functions with different programming.
3. Interface PLC/DCS with SCADA or HMI for developing operator-level visualizations for industrial processes.
4. Implement automation solutions for given industrial applications.

List of Experiments: (students are expected to perform any 8 experiments)
1. Write a PLC program using logical operators for the given control logic.
2. Write a PLC program using timers and counters for a given application.
3. Write a PLC program using advanced PLC Programming for an industrial process.
4. Configure analog I/O and tune a PID loop in PLC for process control loop.
5. Implementing logic functions using ST and FBD PLC programming
6. Interface PLC with SCADA and develop SCADA GUI for an industrial application
7. Interface PLC with HMI and develop GUI for an industrial application
8. Write and execute a DCS program for switching ON/OFF discrete output devices (lamps, buzzers) based on push-button inputs.
9. Implementing a control loop in DCS and develop DCS operator interface
10. Configuration of any Foundation Fieldbus device to PLC and /or DCS system.
11. Configure and implement different alarms in PLC and/or DCS systems.
12. Preparing a HaZOp document for any small process
13. Open Ended Assignment

Or similar type of practical assignments based on the course contents

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23PCIN602L System Engineering and Management Lab

Teaching Scheme
Practical: 2 Hrs/Week

Examination Scheme
In Semester: 25 Marks
Oral: 25 Marks
Credits: 1

Course Outcomes: By the end of the course, students should be able to
1. Prepare project planning and scheduling documents for instrumentation projects using appropriate tools and techniques
2. Apply national and international standards, and recommended practices for interpreting project engineering design documents
3. Analyse instrumentation project engineering design documents
4. Prepare testing and commissioning documentation

List of Practical Assignments:
1. Prepare documents for SOW/WBS/Scheduling document for any I&C Project
2. Interpret the Process flow diagram of the given process.
3. Analyse the given P&ID by applying various standards
4. Prepare the Instrument Index sheet, I/O list for given P&ID
6. Fill in the standard Specification forms for given process control instruments
7. Test a typical control panel (JB/Electrical/ PLC/DCS) as per drawings(GA, power wiring etc) for a given panel
8. Interpret the given hook up drawing (Control valve, Thermowell, orifice plate, DPT etc..) to prepare the bill of material.
9. Analyse the given Loop Wiring Diagram
10. Prepare testing documents like FAT
11. Introduction softwares for developing project design documents.

Or similar type of practical assignments based on the course contents

23PCIN603L Process Data Analytics Lab

Teaching Scheme:
Practical: 2 Hrs/week

Examination Scheme:
In semester: 25Marks
Oral: 25 Marks
Credits: 1

Course Outcomes: Students will be able to
1. Collect process data to create datasets for analytics applications.
2. Apply statistical methods to monitor processes performance.
3. Implement machine learning methods for process monitoring, fault detection, and predictive analytics.
4. Demonstrate industrial analytics processes to identify potential safety risks, ethical issues, data privacy concerns, and security vulnerabilities in compliance with relevant standards.

List of Practical Titles:
1. Explore industrial data types and sources (DCS, PLC, SCADA, MES, ERP, IoT).
2. Data Acquisition from Simulated Process Sensors using PLC/SCADA/DAQ Systems.
3. Construct and interpret Control & Attribute charts for given industrial data.
4. Implement suitable hypothesis tests for a given dataset.
5. Implement Linear Regression for Predicting Process Output.
6. Implementation of classification algorithms for given data.
7. Implementation of Clustering algorithm for Process Data.
8. Implement Association Rule Mining for Fault Pattern Detection
9. Case Study on Ethical Issues in Industrial Data Analytics
10. Open Ended Assignment

Or similar type of practical assignments based on the course contents

Note: Above experiments can be performed in any software/programming languages (MATLAB/Python/R Programming/ etc)

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