COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Engineering and Technology

Curriculum Structure & Detailed Syllabus

Final Year B. Tech.

Instrumentation and Control Engineering

(Effective from: A.Y. 2026-27)

Program Educational Objectives (PEOs)

After the completion of the program,

I. Student will be employable in the diversified sectors of the industry, government organizations, public sector and research organizations.

II. Student will pursue higher education in engineering or other fields of their interests, at institutes of repute and high ranking.

1. Student will demonstrate effective communication, lifelong learning ability, integrity, teamwork, leadership qualities, concern to environment and commitment to safety, health, legal and cultural issues in the fields they choose to pursue.

Program Outcomes (POs):

Engineering Graduate will be able to:

PO1: Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problem.

PO2: Problem Analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science, and engineering sciences.

PO3: Design/Development Solution: Design solution for complex engineering problems and design system component or process that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, social and environmental conditions.

PO4: Conduct Investigation of Complex Problem: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusion.

PO5: Method, Tool Usage: Create, select and apply appropriately technique, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with understanding the limitation.

PO6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to access societal health, safety, legal and cultural and consequent responsibility relevant to the professional engineering practice.

PO7: Environment and Sustainability: Understand the impact of the professional engineering solution in societal and environmental context, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principle and commitment to professional ethics and responsibilities and norms of the engineering practices.

PO9: Individual and Team Work: Function effectively as an individual, and as the member or leader in diverse team and multidisciplinary setting.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, and being able to comprehend and write effective reports and design documentation and effective presentation and give and receive clear instructions.

PO11: Project management and Finance: Demonstrate knowledge & understanding of the engineering and management principles and apply these to one's work, as the member and the leader in a team to manage projects and in multidisciplinary environment.

PO12: Lifelong Learning: Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in broadest context of technological change.

Final Year B. Tech.
Instrumentation and Control Engineering

List of Abbreviations

Abbreviation	Title	No of Courses	Credits	% of Credits
BS	Basic Science Course			
ESC	Engineering Science Course			
PCC	Programme Core Course (PCC)	02	08	23.52
PEC	Programme Elective Course (PEC)	04	12	35.29
OE/SE	Open/School Elective (OE/SE) other than particular program			
MDM	Multidisciplinary Minor (MDM)	01	03	8.82
VSEC	Vocational and Skill Enhancement Course (VSEC)			
HSMC	Humanities Social Science and Management			
IKS	Indian Knowledge System (IKS)			
VEC	Value Education Course (VEC)			
RM	Research Methodology (RM)	01	02	5.88
--	Internship	02	04	11.76
--	Project	01	05	14.70
CEA	Community Engagement Activity (CEA)/Field Project			
CCA	Co-curricular & Extracurricular Activities (CCA)			
	Total	**11**	**34**	**100**

Final Year B. Tech.
Instrumentation and Control Engineering

Semester -VII

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	PCC-15		Process Control	3	0	2	1	4	30	20	50	50	50
2	PCC-16		Project and Engineering Management	2	1	2	1	4	30	20	50	50	50
3	PEC-03		**Program Elective Course-III**	3	0	0	1	3	30	20	50		
			Building Automation										
			Biomedical Signal Processing										
			Industrial Cyber Security										
			Sliding Mode Control										
4	PEC-04		**Program Elective Course-IV**	3	0	0	1	3	30	20	50		
			Batch Process Control										
			Medical Image Processing										
			Industry X.X										
			Applications of Machine Learning										
5	RM-01		Research Methodology	2	0	0	0	2	30	20	50		
6	OJT-02		Internship	0	0	0	0	1				50	50
7	VSEC-03		Project Stage III	0	0	10	0	5				50	50
8	MDM-05		Multidisciplinary Minor	3	0	0	1	3	30	20	50		
Total				16	01	14	05	25					

Semester -VIII

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	PEC-V		Massive Open Online Courses (MOOC - 01)	3	0	0	0	3	30	20	50		
2	PEC-VI		Massive Open Online Courses (MOOCs-02)	3	0	0	0	3	30	20	50		
3	OJT-03/ VSEC - 03		Internship / On Campus Project	0	0	0	0	3				50	50
Total				06	00	00	00	09					

Semester - VII

Process Control						
Course Code			**Examination Scheme**			
Teaching Scheme	2-1-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Analyze process dynamics and develop models using FOPDT/SOPDT representations. [PEO-1], [PO2]
2. Apply system identification and parameter estimation techniques for process modelling. [PEO-1], [PO2]
3. Design and tune PID-based and multivariable control strategies for process systems. [PEO-2], [PO3]
4. Apply AI/ML methods for process modeling, monitoring, and fault detection. [PEO-3], [PO4]

Introduction to Process: **[7 Hrs]**

Types of industrial processes, Process characteristics: dead time, capacity, time constant, Process Reaction Curve (PRC), Step response analysis and time constant estimation, First Order Plus Dead Time (FOPDT) and Second Order (SOPDT) models, Introduction to Statistical Process Control (SPC) concepts

Modeling of Process: **[6 Hrs]**

General modelling principles and assumptions, Degrees of freedom analysis, State variables and state-space representation, Lumped and distributed parameter systems, Transfer function models: steady-state and dynamic behaviour, Empirical modelling approaches, Model validation techniques

System Identification: **[6 Hrs]**

Identification of dynamic processes, Online and offline identification methods, Test signals (step, pulse, PRBS) and their applications, Parameter estimation overview (least squares concept), Overview of identification tools, Model structure selection and validation.

Control System: **[6 Hrs]**

Tuning techniques: Ziegler–Nichols, Cohen–Coon, IMC-based PID tuning, Two-degree-of-freedom (2-DOF) PID control, Anti-windup techniques, Adaptive PID control, Advanced strategies: Cascade, Ratio, Selective, Split-range control

Multivariable and Multiloop control: **[8 Hrs]**

Multivariable system interaction and its effects, Relative Gain Array (RGA) and pairing, Decoupling methods (static and dynamic), Stability of multiloop systems, Handling constraints in multivariable systems

AIML Applications in Process: **[8 Hrs]**

Introduction to AI/ML in process industries, Data-driven modeling vs first-principles modeling, Supervised learning techniques (regression, classification), Neural networks for process modelling and control, soft sensors and fault detection, Case studies of AI/ML/DL applications in process industries.

List of Experiments: Students are expected to perform Minimum 8-10 Experiments:

1. Study and analysis of flow, pressure, and level control loop (Analysis includes process parameters such as type of process, dead time, capacity etc.)
2. Design open loop and close loop control for the given plant.
3. To determine process dynamics using step response and obtain FOPDT model parameters.
4. To analyze process reaction curve and estimate process time constant and dead time.
5. To develop and validate a transfer function model from experimental process data. .
6. To perform system identification using step, pulse, and PRBS test signals.
7. To estimate process model parameters using least squares method.
8. To study PID controller performance and evaluate Ziegler–Nichols and Cohen–Coon tuning methods.
9. To implement IMC-based and 2-DOF PID control and compare system responses.

10. To design and analyze cascade, ratio, and split-range control strategies.
11. To study interaction in multivariable systems and determine RGA-based loop pairing.
12. To develop a simple AI/ML-based soft sensor or prediction model for a process variable.
13. To detect faults in process instrumentation by identifying early signs of stiction and sensor drift for predictive maintenance.

Textbooks:	
[1]	F. G. Shinskey, "Process Control System", 1st Edition, McGraw Hills Publication, 1996.
[2]	B. G. Liptak , "Process Control", 4th Edition, Chilton Publications, 2009.
[3]	F. G. Shinskey, "Feedback controllers: Tuning, Applications & Design", 4th Edition, McGraw-Hill, 1998.
Reference Books:	
[1]	G. Stephanopolous, "Chemical Process Control", 5th Edition Prentice Hall of India, 2001
[2]	Douglas M. Considine, "Process Instrumentation and control Handbook", 1st Edition, McGraw-Hill, 1984
[3]	B. Wayne Bequette," Process Control: Modeling, Design, and Simulation" by, 2nd Edition

Project and Engineering Management						
Course Code			**Examination Scheme**			
Teaching Scheme	2-1-2-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Understand basics of engineering management and project organization structure.
2. Identify the tools of Project Management, Planning, and scheduling.
3. Illustrate the integration of PMIS with modern safety system.
4. Apply the standards in the project development.
5. Interpret the design information from the documents.

Introduction: **[7 Hrs]**

Introduction - Definition and objectives of Project Management, Types and classification of projects, Life cycle phases of the project, Interactions involved in Project and their coordination. EPCM Contracting in Project Engineering Management, Responsibilities in EPCM – Engineering, Procurement planning and Management, Inspection & Quality Control, Site Delivery & Storage , Supply Chain & Logistics Construction Management. Organization Structure: Role and responsibilities of the project manager, functional team members.

Methods and Functionalities: **7 Hrs]**

Classical and Agile Learning method in Project Engineering Management. Functionalities Planning - WBS, Scheduling - critical path, Cost Management - EVM integration, Progress Monitoring - project tracking, Resource Management – Manpower and Equipment, Documentation & Reporting.

Project Management Software: **[7 Hrs]**

Introduction to PM software like Primavera P6, Microsoft Project, Asta Powerproject. People Management Skills, Risk Management, Risk-Based Scheduling in Projects.

Modern Safety in project engineering Management **[7 Hrs]**

8 pillars of modern safety standards, Global Safety Standards & Frameworks, Occupational Safety and Health Administration (OSHA) – workplace safety International Organization for Standardization – ISO 45001 (OH&S), ISO 14001 (environment). Process Safety Management (PSM) – Hazard identification (HAZID, HAZOP), Safety Instrumented Systems (SIS), Relief systems & interlocks, Management of Change (MOC). Functional Safety & SIL Based on IEC 61511. ESG Sustainability and digital safety.

List of Experiments: Students are expected to perform Minimum 8-10 Experiments:

1. Study of standards and symbols (ANSI / ISA S-5.1).
2. Preparation of Process Flow diagram.
3. Development of Piping and Instrument diagram (P&ID) as per ISA 5.1,2.3 standard.
4. Development Instrument index sheet for a P&ID.
5. Development of I/O terminal sheet for a P&ID.
6. Development of specification sheets for transmitters and actuators (ISA S-20 Format).
7. Development of a loop wiring diagram.
8. Development of a Hook up drawings for installation of transmitters and control valve.
9. Development of a Cable schedule for few loops in P&ID
10. Development of Junction box and marshalling cabinet cabling layout.
11. Development GA and mimic diagram of a control panel.
12. Development of cause-and-effect diagram for control programming.

Textbooks:	
[1]	A. Lester, Project Management, Planning and Control: Managing Engineering, Construction and Manufacturing Projects to PMI, APM and BSI Standards, 8th ed. Oxford, UK: Butterworth-Heinemann, 2021.
[2]	W. Larson, An Elegant Puzzle: Systems of Engineering Management. San Francisco, CA, USA: Stripe Press, 2019.
Reference Books:	
[1]	J. M. Nicholas and H. Steyn, Project Management for Engineering, Business and Technology, 6th ed. New York, NY, USA: Routledge, 2020.
[2]	H. Kerzner, *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, 13th ed. Hoboken, NJ, USA: John Wiley & Sons, 2022.
[3]	Instrumentation and Control Symbols and Identification, ANSI/ISA-5.1-2024, 2024.
[4]	Binary Logic Diagrams for Process Operations, ISA-5.2-1976 (R1992), 1992.
[5]	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems, ISA-5.3-1983, 1983.

Program Elective Course-III

Building Automation						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	-	-	--

Course Outcomes: Students will be able to:

1. Identify the components and understand basics of Building Automation System.
2. Demonstrate and explain HVAC, Access Control and Fire Alarm System.
3. Devise and select components & equipment used in these systems.
4. Illustrate the integration of protocols and BMS elements for system.

Introduction to intelligent buildings and Building automation systems: **[7 Hrs]**

Intelligent building, Intelligent architecture and structure, Facilities management vs. intelligent buildings, Lifecycle of building, Evolution of intelligent buildings. BAS System Hierarchy –Field level components, Direct Digital Control (DDC), Supervisory Controller, Server, Operator Workstation (OWS).

Different systems in BAS which includes HVAC, security, fire, and lighting systems. Importance of each system in BAS. Process of BAS design, Role of different stakeholders (Architect, contractor, consultant, application engineer and engineer) in BAS System design, Comfort parameters for human being- temperature, humidity, flow, pressure, clean air, CO2%.

HVAC Basic Concepts- Systems (Air Side)- Air handling unit: **7 Hrs]**

Concept of Air handling unit. Design, working of different components in AHU- damper, filter, cooling coil, heating coil, fan, heat recovery wheel, humidifier. Working, configuration, characteristics for different types of dampers. Damper Sizing, Design and working of different types of AHU. Operation of different modes. Concept of Variable Air Volume (VAV) system-Design, working, use of different types of VAV- CAV, Design, working, use of radiation coil, chilled beam, CRAC unit, VRV systems, unit heater, Fan coil unit and unit ventilator.

HVAC Basic Concepts- Systems (Plant Side)- Chilled water system & Hot water system: **[7 Hrs]**

Chilled Water Systems: Working, mechanical configuration of different types of components used in refrigeration cycle- evaporator, condenser, compressor, expansion valve. Working, mechanical configuration of different types of cooling towers, Sequencing of chilled water plant.

Hot water systems: Working and design of different types of boilers Control of boiler- 7 element control, fuel-air ratio control. Working, design of different types of hot water system- with boilers, heat exchanger with steam input, heat exchanger, Sequencing of Boiler Plant.

BMS Protocols and Architecture: **[7 Hrs]**

Open Protocols -BACnet, LON, Profibus, Modbus, M-bus, Proprietary Protocols- N2, CBUS, Introduction to wired and wireless BMS architecture– Wireless filed devices, controllers, routers, coordinators.

Access Control System: **[7 Hrs]**

Concept of automation in access control system for safety. Physical security system with components, RFID enabled access control with components. Computer system access control – DAC, MAC, RBAC.

Fire & Alarm System:	**[7 Hrs]**
Different detectors and their types. Different types of Fire control panels. Design considerations for the addressable FA system. Concept of IP enabled Fire& Alarm system.	
Textbooks:	
[1]	S. Wang, Intelligent Buildings and Building Automation. New York, NY, USA: Routledge, 2009.
[2]	J. Sinopoli, Smart Buildings Systems for Architects, Owners and Builders. Burlington, MA, USA: Butterworth-Heinemann, 2010.
Reference Books:	
[1]	R. A. Carlson and R. A. Di Giandomenico, *Understanding Building Automation Systems: Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs*. Lilburn, GA, USA: Fairmont Press, 1991.
[2]	A. Bahman, *Industrial Fire Detection and Alarm Systems: A Guide for Engineers and Managers*. Boca Raton, FL, USA: CRC Press, 2024.
Note:	

Biomedical Signal Processing						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	-	-	--

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

1. Understand the fundamentals of biomedical signals and their characteristics & apply signal processing techniques such as filtering, sampling, and spectral analysis to biomedical signals
2. Analyze and interpret biomedical signals in time and frequency domains
3. Design and implement digital filters for noise removal and signal enhancement
4. Utilize software tools for processing and visualization of biomedical data
5. Evaluate real-world biomedical signal processing applications in monitoring systems & diagnosis

Introduction to Biomedical Signals **[7 Hrs]**

Action Potential and Its Generation, Origin and Waveform Characteristics of Basic Biomedical Signals such as : Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG), Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG), Objectives of Biomedical Signal Analysis, Challenges in Biomedical Signal acquisitions & Analysis, Computer-Aided Diagnosis.

Removal of Noise and Artifacts from Biomedical Signal **[7 Hrs]**

Random and Structured Noise, Physiological Interference, Stationary and Nonstationary Processes, Noises and Artifacts Present in ECG, Time and Frequency Domain Filtering.

ECG & EEG Signal Processing and Event Detection in Biomedical Signals **[7 Hrs]**

EEG Signal and Its Characteristics, EEG Analysis, Linear Prediction Theory, Autoregressive Method, Sleep EEG, Application of Adaptive Filter for Noise Cancellation in ECG and EEG Signals; Detection of P, Q, R, S and T Waves in ECG, EEG Rhythms, Waves and Transients, Detection of Waves and Transients, Correlation Analysis Ad Coherence Analysis of EEG Channels.

Analysis of Non-stationary Signals **[7 Hrs]**

Heart Sounds and Murmurs, Characterization of Non-stationary Signals and Dynamic Systems, Short-Time Fourier Transform, Considerations in Short-Time Analysis and Adaptive Segmentation.

Feature Extraction & Signal Processing Applications **[7 Hrs]**

Signal averaging techniques, Feature extraction methods, Pattern recognition basics, Data compression techniques, Biomedical Signal Classification

Applications of Biomedical Signal Processing **[7 Hrs]**

Introduction to machine learning in biomedical signals, EEG signal analysis and brain-computer interface, Medical diagnosis systems using signal processing, Case studies in healthcare monitoring systems & diagnosis

Textbooks:

[1]	Rangayyan R. M., Biomedical Signal Analysis, John Wiley & Sons, 2015
[2]	Reddy D.C., Biomedical Signal Processing: Principles and Techniques, McGraw-Hill, 2005
[3]	Tompkins W. J., Biomedical Digital Signal Processing, Editorial Prentice Hall, 1993
[4]	Leif Sörnmo and Pablo Laguna, Bioelectrical Signal Processing in Cardiac and Neurological Applications, Academic Press, 2005

Industrial Cyber Security						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	--	--	--

Course Outcomes: Students will be able to:

- Understand knowledge of security mechanisms, standards and state-of–the-art capabilities.
- Design new systems and infrastructure level security solutions.
- Develop and maintain new tools and technologies to enhance the security of applications in industrial automation.
- Identify and solve different cyber security threats

Introduction **[6 Hrs]**

Industrial Automation Fundamental Concepts , IT OT Differences, Understanding Purdue Model in OT, Understanding Level 0,1,2,3, 3.5 DMZ, Industrial automation protocol summary (Wired and Wireless): Modbus/TCP, EtherNet/IP, DNP, HART, OPC, PROFIBUS, PROFINET, BACnet, ICCP, MMS, Goose Messaging, WirelessHART, ISA 100, Bluetooth, Zigbee

Hardware Attack **[7 Hrs]**

Safety and OT Security requirements as per IEC 61511 and IEC62443: No Safety without Security. Understanding OT Network Attack Surface (Hardware to Cloud), Common OT Network Vulnerabilities, Understanding Cyber Kill Chain, Example Attack Demonstration

Software Attack **[7 Hrs]**

Understanding Attacks on OT Protocols: Attacks on Modbus, EtherNet/IP, PROFINET (Replay, scanning, enumeration, DOS, MiTM Attack, Crafting Discovery Packets using scapy, Fuzzing)

Security Techniques **[10 Hrs]**

Securing OT Network: Understanding Security Controls (Physical Security, Segmentation, Patch Management, Remote Access, End Point Security, IDS, Awareness/Training, Removable Media, Application Whitelisting, Hardening and few more)

Security Standards **[6 Hrs]**

Standards, Guidelines, Frameworks, Regulations – NIST, ISA/IEC 62443

Risk Management **[6 Hrs]**

OSINT for ICS, Understanding OT Visibility, Log Monitoring and Management, Risk Assessment and Risk Management, Understanding MITRE Attack Framework, Understanding Zero Trust Architecture

Textbooks:

[1]	Industrial Automation and Control System Security Principles: Protecting the Critical Infrastructure by Ronald L. Krutz 2nd Edition, International Society of Automation, 2017.
[2]	Industrial Network Security by David J. Teumim Second Edition International Society of Automation, 2010.

Reference Books:

[1]	Industrial Data Communications by Lawrence M. Thompson and Tim Shaw Fifth Edition, International Society of Automation, 2015.
[2]	Implementing IEC 62443: Best Practices for OT Security Professionals by Abhirup Guha Publisher-Notion Press

Sliding Mode Control						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	-	-	--

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

- **Explain** the fundamental concepts of sliding mode control, including variable structure systems, sliding surfaces, and stability using Lyapunov theory.
- **Apply** chattering reduction techniques and adaptive control methods to improve system robustness under uncertainties.
- **Design and analyze** terminal and fixed-time sliding mode controllers for nonlinear systems.
- **Develop** higher-order sliding mode controllers to achieve reduced chattering and improved performance.
- **Implement** intelligent sliding mode control techniques using neural networks and fuzzy logic for handling complex nonlinear systems

Introduction to Sliding Mode Control :	**[7 Hrs]**

Concept of variable structure systems, Sliding surface and reaching phase, Advantages and limitations of SMC, First-order SMC design, Reaching law approach, Equivalent control concept, Filippov solution, Stability analysis.

Chattering Reduction Techniques:	**[7 Hrs]**

Causes of chattering, Boundary layer approach, Continuous approximations, Dynamic sliding manifolds, Integral sliding mode control, Quasi-Sliding Mode, Super-Twisting Control, Prescribed Convergence Law, Disturbance rejection capabilities, Adaptive Sliding Mode Control: Parameter uncertainty handling, Adaptive laws for gain tuning, Stability and convergence analysis.

Improved Sliding Mode Control	**[7 Hrs]**

Sliding mode control based on reaching law, Reaching phase elimination, Time Varying Sliding Surfaces, Optimal switching surface selection using Linear Quadratic Regulator (LQR), State Dependent Riccati Equation (SRDE), Modified Reaching Law: nonlinear or fractional-order reaching laws, Backstepping technique.

Terminal Sliding Mode Control:	**[7 Hrs]**

Finite-time convergence concepts, Terminal sliding surfaces, Design procedures and stability Applications in nonlinear systems, Fixed-Time Terminal Sliding Mode Control, Fixed-time stability theory, Design of fixed-time sliding surfaces, Comparison with finite-time control

Uncertainty Estimation	**[7 Hrs]**

Shift operator and delta operator, Discrete sliding mode control, Unified sliding condition, Unified sliding mode theory Methods of uncertainty estimation, inertial delay control.

State and Disturbances Observer	**[7 Hrs]**

State observers, disturbance observers, sliding mode observer, sliding mode state and disturbances observer, Some case studies

Textbooks:

[1]	Slotine and W.LI, “Applied Nonlinear Control”, 1st Edition, Prantince Hall, Engloe wood NewJersey 1991.
[2]	J. Liu, Sliding Mode Control Using MATLAB. London, U.K.: Academic Press, 2017.

Reference Books:

[1]	Y. Shtessel, C. Edwards, L. Fridman, and A. Levant, *Sliding Mode Control and Observation*, New York, NY, USA: Birkhäuser, 2013. doi: 10.1007/978-0-8176-4893-0.
[2]	C. Edwards and S.K. Spurgeon, "Sliding Mode Control: Theory and Applications", Taylor & Francis, 1998.
[3]	G. Bartolini, L.Fridman, A. Pisano and E. Usai (Ed.), "Modern sliding mode control theory", Springer, 2008.

Program Elective Course-IV

Batch Process Control						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	---	---	--

Course Outcomes: Students will be able to:

- Understanding batch process terminologies, operation
- Acquired knowledge of standards used for batch process control
- Development of control schemes for different batch process applications
- Evaluate performance for the developed solution

Unit I	**[6 Hrs]**
Introduction: Introduction to batch control system, batch control system terminology, characteristics of batch processes, hierarchical batch model, control structure for batch systems.	
Unit II	**[6 Hrs]**
Batch Control System: Terminology, Typical Functions 'Interlocking, Calculations, Batch Sequence control (Heating-Mixing-transfer), Scheduling and tracking of multiple units, Adjusting set points', HW & SW challenges, Equipment, Process actions.	
Unit III	**[7 Hrs]**
S88 Standard: Need for standards, Batch Control Language Requirements, FDA Validation, Code of Federal Regulations (CFR), Good Manufacturing Practice, GAMP Life Cycle, Compliance to 21 CFR Part 11, Introduction to S88 standard, S88 Models, Physical model, Control activity model, Procedural control model, Process model, advantages of S88 standard	
Unit IV	**[6 Hrs]**
S95 Standard: Need for S95 Standard, Hierarchical and Functional Model, Object Model Attributes, Models of Manufacturing Operations Management, Business to manufacturing transactions	
Unit V	**[7 Hrs]**
Design of batch control systems: Batch Management Model and its Functions, Recipe Management, Recipe Classifications, Recipe Structure, Information/display requirements, cost justification and benefits, data management.	
Unit VI	**[10 Hrs]**
Batch Control System Implementation, and case studies: Batch Control System Requirements, Specifications, Design, System Hardware and Reliability Requirements, Batch Control System Implementation, case study of batch control system implementation for applications in food and beverages, pharmaceuticals	

Textbooks:

[1]	Batch Control Systems by Thomas.G. Fisher William M. Hawkins ISA series, 1 st ed., 2008.

Reference Books:

[1]	Process Control, Instrument Engineering Handbook by B G Liptak, CRC Press
[2]	Process Software and Digital Network Handbook by B G Liptak, CRC Press

Medical Image Processing and Analysis						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	-	-	--

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

- Understand the characteristics of biomedical images and apply spatial and frequency domain techniques for image enhancement.
- Analyze and implement image segmentation techniques and extract relevant features for biomedical applications.
- Evaluate and apply image restoration, deblurring, and reconstruction techniques for medical imaging modalities such as CT and MRI.
- Interpret biomedical images using quantitative analysis and apply methods for object recognition, classification, and computer-aided diagnosis.
- Develop and implement biomedical image processing algorithms using tools such as MATLAB or Python, etc. and analyze real-world medical image datasets.

Fundamentals of medical Imaging **[7 Hrs]**

Introduction to biomedical images, Image formation in medical imaging systems, Basics of digital image processing, Image sampling and quantization, Image representation and storage, Types of biomedical images such as X-ray, CT, MRI, Ultrasound, etc.

Image Enhancement Techniques **[7 Hrs]**

Spatial domain methods, Point processing - contrast stretching &histogram equalization, Spatial filtering –smoothing & sharpening, Frequency domain methods, Fourier transform, Frequency filtering, Noise models in biomedical images, Noise reduction techniques

Image Segmentation **[6 Hrs]**

Introduction to segmentation, Thresholding techniques, Edge detection, Region-based segmentation, Watershed segmentation, Morphological operations

Feature Extraction & Image Analysis **[7 Hrs]**

Feature extraction techniques, Shape features, Texture features, Intensity-based features, Dimensionality reduction basics, Pattern recognition fundamentals, Feature selection methods

Image Restoration & Reconstruction **[7 Hrs]**

Image degradation model, Image restoration techniques, Inverse filtering, Wiener filtering
Image deblurring, Reconstruction techniques in – CT, MRI basics, Introduction to inverse problems

Advanced medical Image Analysis **[7 Hrs]**

Object recognition and classification, Machine learning basics in medical imaging, Computer-aided diagnosis (CAD) systems, Introduction to deep learning in medical imaging, Case studies such as tumor detection, organ segmentation , etc., Implementation using MATLAB / Python, etc.

Textbooks:

[1]	Rangaraj M. Rangayyan, Biomedical Image Analysis, CRC Press
[2]	Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, Pearson Education International
[3]	Nikolaos Paragios, James S. Duncan, Nicholas Ayache, Handbook of Biomedical Imaging: Methodologies and Clinical Research, Springer Science& Business Media
[4]	Chirag Paunwala, Mita Paunwala, Rahul Kher, Falgun Thakkar, Heena Kher, Mohammed Atiquzzaman, Norliza Mohd. Noor, Biomedical Signal and Image Processing with Artificial Intelligence, Springer, Cham, 1st edition 2023

Application of Machine Learning						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Understanding the Artificial Intelligence (AI) and Machine Learning (ML) fundamentals
2. Supervised, unsupervised, and semi supervised machine learning algorithms
3. Study of data preprocessing and transformation techniques Understanding the various models related to process control applications
4. Development of data-based controls for Process Control Applications

Conceptual Introduction:	**[4 Hrs]**
Artificial Intelligence (AI) Fundamentals, defining AI techniques	
Machine Learning Methods and Algorithms:	**[10 Hrs]**
Introduction to Machine Learning, classification of Machine Learning algorithms, regression and classification, Linear regression (Simple and Multiple), Logistic regression, Decision tree (Regression and classification), SVM, K means Clustering, Hierarchical Clustering, KNN Classifier.	
Process of building ML Models:	**[8 Hrs]**
Supervised, unsupervised and semi-supervised learning, Algorithms. Concepts, instances and attributes, training and testing data, Libraries for ML.	
Data Preparation and Model Training:	**[6 Hrs]**
Gradient descent algorithm, cost function, Activation functions, data preprocessing and transformation techniques	
Reinforcement Learning:	**[6 Hrs]**
Fundamentals of Reinforcement Learning (agent, environment, rewards, policy), Markov Decision Process and value functions, Dynamic programming basics (policy/value iteration concepts), Model-free methods: Monte Carlo and Temporal Difference learning.	
Applying Machine Learning in Industry:	**[8 Hrs]**
Data based Controls and ML based controls for Process Control Applications.	

Textbooks:

[1]	Tom Mitchell, "Machine Learning", McGraw-Hill, 1997
[2]	Ethem Alpaydin, "Introduction to Machine Learning", PHI, 2005.

Reference Books:

[1]	Bishop, C., "Pattern Recognition and Machine Learning:," Berlin: Springer-Verlag, 2006
[2]	K.P. Soman, R. Longonathan and V. Vijay, "Machine Learning with SVM and Other Kernel Methods", PHI
[3]	Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer 2006.

Research Methodology						
Course Code			**Examination Scheme**			
Teaching Scheme	2-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	2		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

- Explain the concept, characteristics, and applications of research.
- Identify and formulate a research problem and research objectives.
- Understand the research process and types of research hypotheses.
- Organize and critically review literature sources

Introduction to Research: **[7 Hrs]**

The concept of research, characteristics of good research, Application of Research, Meaning and sources of Research problem, characteristics of good Research problem, Research process, outcomes, application of Research, Meaning and types of Research hypothesis, Importance of Review of Literature, Organizing the Review of Literature.

Types of Research: **[7Hrs]**

Types of research, pure (basic, fundamental) and applied research, qualitative and quantitative. Research Design: Meaning, need, types of research design – Exploratory, Descriptive, Casual research Design, Components of research design, and Features of good Research design. Experiments, surveys and case study Research design

Sampling, Data Collection and analysis: **[7 Hrs]**

Types and sources of data – Primary and secondary, Methods of collecting data, Concept of sampling and sampling methods – sampling frame, sample, characteristics of good sample, simple random sampling, purposive sampling, convenience sampling, snowball sampling, classification and tabulation of data, graphical representation of data, graphs and charts – Histograms, frequency polygon and frequency curves, bell shaped curve and its properties. Statistical Methods for Data Analysis : Applications of Statistics in Research, measures of central tendency and dispersion

Technical writing **[7 Hrs]**

Research report and its structure, journal articles – Components of journal article. Explanation of various components. Structure of an abstract and keywords. Thesis and dissertations. components of thesis and dissertations. Referencing styles and bibliography.

Textbooks:

[1]	Business Research Methods By Donald R. Cooper & Pamela S. Schindler, 9th Edition, Tata McGraw-Hill, 2009
[2]	Research Methodology: Methods and Techniques By C. R. Kothari New Age International Publishers
[3]	Research Methods for Business By Uma Sekaran 4th Edition, Wiley, 2010

Project Stage-III					
Course Code		Examination Scheme			
Teaching Scheme	Practical: 6 hrs/week	Theory	TA: -	MSE:	
Credits	-	Laboratory	CIE: 50	ESE: 50	
Course Outcomes : At the end of the course, students will demonstrate the ability to:					
1. Design, develop and integrate complete system based on Stage-II work. 2. Validate system performance with testing and optimization. 3. Demonstrate the leadership quality along with ability to work in a group. 4. Prove the ability to present the findings in a written report or oral presentation					

Project Development & Scope	
Technical Development	Students will complete the full system design initiated in Stage-II. This includes integration of all modules, optimization, reliability testing, and validation as per industrial standards. Emphasis is on real-time performance, data analysis, and robustness of the system.
Execution	The focus will be on final implementation, debugging, system integration, and demonstration of a working prototype.
Planning & Deliverables	Students must submit a complete project report, working prototype, research paper (if applicable), presentation, and logbook documenting progress.
Evaluation System	
Internal Continuous Assessment (ICA)	Evaluated by the course based on progress, implementation, and contribution in the group, project deliverables and depth of understanding
End Semester Examination (ESE)	Based on the demonstration of the system or sub-system, project deliverables, and an oral examination. Evaluated by two examiners (one internal and one external)

Internship					
Course Code		Examination Scheme			
Teaching Scheme	Practical: 6 hrs/week	Theory	TA: -	MSE:	
Credits	-	Laboratory	CIE: 50	ESE: 50	
Course Outcomes : At the end of the course, students will demonstrate the ability to:					
• Demonstrate an understanding of industrial practices, challenges, and work ethics. • Apply theoretical and technical knowledge to practical, real-world industry problems. • Work collaboratively in professional environments and communicate effectively. • Identify gaps in their knowledge and acquire new skills relevant to industry requirements. • 5. Prepare detailed documentation and deliver technical presentations based on internship work.					

Internship Guidelines & Expectation
Overview & Expectations
During the internship, students are expected to engage in structured industrial training under the supervision of qualified professionals. The training should provide exposure to real-time work environments and organizational practices relevant to the student's field of study
Activities & Workplace Norms
Activities may include observing and participating in ongoing projects, assisting in technical or managerial tasks, familiarizing themselves with industry-standard tools and technologies, and understanding workflow processes. Students are required to maintain a professional attitude, adhere to workplace norms and safety regulations, and demonstrate effective communication and teamwork skills.
Deliverables & Evaluation
Throughout the internship period, students must document their experiences and learning outcomes in a logbook provided by department, culminating in a detailed internship report and a presentation to be evaluated by a faculty panel.

Semester - VIII

Program Elective Course-V and VI

MOOC Course:

1. Electric vehicles and Renewable energy , IIT Madras Prof. Ashok Jhunjhunwala Prof. Prabhjot Kaur Prof. Kaushal Kumar Jha, Prof. L Kannan
2. Deep Learning - IIT Ropar, IIT Ropar, Prof. Sudarshan Iyengar

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Internship					
Course Code		Examination Scheme			
Teaching Scheme	Practical: 6 hrs/week	Theory	TA: -	MSE:	
Credits	-	Laboratory	CIE: 50	ESE: 50	
Course Outcomes : At the end of the course, students will demonstrate the ability to:					
• Demonstrate an understanding of industrial practices, challenges, and work ethics. • Apply theoretical and technical knowledge to practical, real-world industry problems. • Work collaboratively in professional environments and communicate effectively. • Identify gaps in their knowledge and acquire new skills relevant to industry requirements. • Prepare detailed documentation and deliver technical presentations based on internship work.					

Internship Guidelines & Expectation
Overview & Expectations
During the internship, students are expected to engage in structured industrial training under the supervision of qualified professionals. The training should provide exposure to real-time work environments and organizational practices relevant to the student's field of study
Activities & Workplace Norms
Activities may include observing and participating in ongoing projects, assisting in technical or managerial tasks, familiarizing themselves with industry-standard tools and technologies, and understanding workflow processes. Students are required to maintain a professional attitude, adhere to workplace norms and safety regulations, and demonstrate effective communication and teamwork skills.
Deliverables & Evaluation
Throughout the internship period, students must document their experiences and learning outcomes in a logbook provided by department, culminating in a detailed internship report and a presentation to be evaluated by a faculty panel.

Probable MOOC – Sem VII

Industry X.X: MOOC Course: Introduction to Industry 4.0 and Industrial Internet of Things, IIT Kharagpur, Prof. Sudip Misra

Probable MOOC – Sem VIII

1. Electric vehicles and Renewable energy , IIT Madras Prof. Ashok Jhunjhunwala Prof. Prabhjot Kaur Prof. Kaushal Kumar Jha, Prof. L Kannan
2. Deep Learning - IIT Ropar, IIT Ropar, Prof. Sudarshan Iyengar