COEP Technological University Pune
(A Unitary Public University of Govt. of Maharashtra)

School of Engineering and Technology

Curriculum Structure & Detailed Syllabus

M. Tech. In Automation

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.

III. 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.

M. Tech. In Automation

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)			
PEC	Programme Elective Course (PEC)			
OE/SE	Open/School Elective (OE/SE) other than particular program			
MDM	Multidisciplinary Minor (MDM)			
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)			
--	Internship			
--	Project			
CEA	Community Engagement Activity (CEA)/Field Project			
CCA	Co-curricular & Extracurricular Activities (CCA)			
	Total			

M. Tech. In Automation
Instrumentation and Control Engineering

Semester -I

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PSMC-01	*IAM-24001*	Probability and Statistics	3	0	0	1	3	30	20	50		
02	PCC-01	*IAM-25001*	Instrument Design Engineering	3	0	0	1	3	30	20	50		
03	PSBC-01	*IAM-24003*	Industrial Automation	3	0	0	1	3	30	20	50		
04	LC-01	*IAM-24005*	Probability and Statistics*	0	0	2	0	1	--	--	--		
05	LC-02	*IAM-25002*	Instrument Design Engineering*	0	0	2	0	1	--	--	--		
06	LC-03	*IAM-24007*	Industrial Automation*	0	0	2	0	1	--	--	--		
07	PEC-01		Elective-I	3	0	0	1	3	30	20	50		
08	PEC-02		Elective-II	3	0	0	1	3	30	20	50		
09	MLC-01	*SET-25003*	Seminar	0	0	2	0	1	--	--	50		
10	MLC-02	*SET-25004*	Technical Writing	0	0	2	0	1	--	--	50		
11	PSBC-02	*IAM-24004*	Modelling and Simulation Laboratory	0	1	2	0	2	--	--	--		
12	MLC-02	*SET-25001*	Research Methodology and IPR	2	1	0	1	3	30	20	50		
Total Academic Engagement and Credits				**17**	**3**	**10**	**6**	**25**					

Program Elective Course-I

1. Process Control and Applications
2. Embedded Systems
3. Industrial networking protocol and Standards

Program Elective Course-II

4. Modern Control Theory
5. Robotics and Automation
6. Soft Computing
7. Sensors and Actuators

Semester -II

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	OE-01		Open Elective	3	0	0	0	3					
02	PCC-02	*IAM-25003*	Industrial Cyber security	3	0	0	1	3	30	20	50		
03	PCC-03	*IAM-25004*	Artificial Intelligence and Machine Learning	3	0	0	1	3	30	20	60		
04	PCC-04	*IAM-25005*	Building Automation	3	0	0	1	3	30	20	50		
05	LC-04	*IAM-25006*	Industrial Cyber security*	0	0	2	0	1	---	--	--		
06	LC-05	*IAM-25007*	Artificial Intelligence and Machine Learning*	0	0	2	0	1	--	--	--		
07	LC-06	*IAM-25008*	Building Automation*	0	0	2	0	1	--	---	--		
08	PEC-03		Elective-III	3	0	0	0	3	30	20	50		
09	PEC-04		Elective-IV	3	0	0	0	3	30	20	50		
10	AEC		Effective Technical Communication Skills and Self Awareness	1	0	2	1	2	--	--	--		
11	LLC-01		Liberal Learning Course	1	0	0	0	1	--	--	--		
Total Academic Engagement and Credits				**20**	**0**	**8**	**4**	**24**					

Department Electives-III and IV

1. Advanced Control System
2. Mechanics and Control of Robotic Manipulators
3. Modeling and Optimization
4. Introduction to Manufacturing Systems Management (NPTEL)
5. Advanced Digital Signal Processing
6. Batch Process Control
7. Industrial Drives and Control
8. Industrial Internet of Things

Semester -III

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	VSEC-02		Dissertation Phase – I	--	--	22	12	11	--	--	100	--	--
02	SLC-01		Massive Open Online Course -I	3	--	--	1	3	--	--	--	--	--
03	SLC-02		Massive Open Online Course-II	3	--	--	1	3	--	--	--	--	--
04	OJT		Internship	--	--	--	--	3	--	--	--	--	--
Total Academic Engagement and Credits				**6**	**--**	**22**	**14**	**20**					

Semester -IV

Sr. No	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	VSEC-03		Dissertation Phase – II	--	--	22	12	11	--	--	100	--	--
Total Academic Engagement and Credits				**--**	**--**	**22**	**12**	**11**	**--**	**--**	**--**	**--**	**--**

- Exit option to qualify for Certification:
  - <Name of the course> (3 Credits)
  - <Name of the course> (3 Credits)

Semester - I

Probability and Statistics						
Course Code	IAM-24001		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Introduce foundational concepts in descriptive statistics.
2. Understanding the basic concepts of probability theory, random variables and probability distributions,
3. Equip students with knowledge and tools for hypothesis testing
4. Enable students to apply statistical methods to analyze data, test hypotheses, and build predictive models.

Descriptive Statistics:

Data Visualisation, Measures of Central Tendency, Measures of Variability

Probability:

Probability – Introduction and Basics, Conditional probability, Bayes' theorem

Probability Distributions:

Random variables – Discrete & Continuous (single and multiple), Probability Distributions Functions, Cumulative Distribution Functions, Continuous Distributions: Normal Distribution, Central Limit Theorem, Sampling Distributions, Discrete Distributions: Binomial Distribution, Poisson Distribution, Prediction based on Parametric Distributions.

Testing of Hypothesis:

Sampling & Estimation, Workflow of Hypothesis testing, Type I, Type II errors, alpha, beta, Confidence and Power, Two tailed and One Tailed Hypothesis, Testing of Hypothesis – Mean – One Sample t-test, two-sample t test, Z test, Testing of Hypothesis – Proportions – one and several Proportions, Chi-Squared Test, ANOVA. One-way ANOVA, Two-way ANOVA

Regression:

Covariance, Correlation, Method of Least Squares, Simple Linear Regression, Assumptions of Linear Regression, Model validation, Multiple Linear Regression, Logistic Regression

Textbooks:

[1]	V.K. Rohatgi & A.K. Md. E. Saleh, "An Introduction to Probability and Statistics",
[2]	Hogg, R. V., Tanis, E. A. & Zimmerman D. L., "Probability and Statistical Inference" Pearson
[3]	Hogg, R. V., Tanis, E. A. & Zimmerman D. L., "Probability and Statistical Inference" Pearson

Reference Books:

[1]	Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Academic Press imprint of Elsevier
[2]	R.E. Walpole, R.H. Myers, S.L. Myers, Keying Ye, "Probability and Statistics for Engineers and Scientists", Prentice Hall
[3]	D. C. Montgomery and G.C. Runger, "Applied Statistics and Probability for Engineers", 5th edition, John Wiley & So

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[2] [3]	To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
[4]	To measure CO3, questions will be based on applications of core concepts.
[5]	To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc. To measure CO5, some questions may be based on self-study topics and comprehension of unseen passages.

Instrument Design Engineering						
Course Code	IAM-25001		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Analyze and justify the requirement of Instrument and systems.
2. Design various electronic circuits and measurement systems, noises identification and appropriate elimination methods related to instruments and systems.
3. Select, design appropriate enclosure, cables, PCB.
4. Estimate, analyze, improve the reliability of instruments and system.

Electromagnetic Compatibility:

Noise, Interference, Noise Coupling, cabling, grounding, grounding, grounding, grounding, ground loops, balancing and filtering Shielding: Near field, far field, absorption losses, and reflection losses

Contact Protections:

Arc discharge, Glow discharge, intrinsic noise sources, active device noise, and digital circuit grounding.

EMC Applications:

Digital circuit power distribution, Digital circuit radiation, Conducted emissions, RF and transient immunity, electrostatic discharge, PCB layout and design, EMC measurements. Standards, reliability, automated test equipment.

Reference Books:

[1]	Henry W Ott, Electromagnetic Compatibility Engineering, John Wiley and Sons Inc. Publication,
[2]	2009 W. C. Bosshart, ―PCB Design and Technology Tata McGraw Hill, 1987
[3]	Clyde F. Coombs, Electronic Instrument Handbook, McGraw Hill, Third Edition, 2005

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Industrial Automation						
Course Code	IAM-24003		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Apply the knowledge of automation in the field of industrial process control.
2. Design the plant-wide architecture of the control system for a process industry.
3. Develop network architecture and detailed specifications of network components.
4. Solve engineering solution for fast growing industrial sector with reliable atomized system using PLC and DCS system.

Course Contents:

Different types of processes. Typical examples of continuous, batch, discrete and hybrid processes. Study of Process flow, detailed P&ID, Critical loops, Safety and Alarms, Reliability and Fail-safe operation requirements, efficient running and adhering to standards. Introduction to Safety terminologies: Risk Assessment, Safety Assessment, Layers of Protection. Lifecycle Concepts and Management of Functional Safety.

Role of automation in industries, Benefits of automation. Distributed Control Systems (DCS) system architecture, system elements, data communication links, DCS Engineering and Design, detailed engineering, specifications, configuration and programming, functions including database management, reporting, Sequential event recording alarm management, communication, third party interface, control, display etc. Enhanced functions viz. Advance Process Control, Batch application, Historical Data Management, OPC support, Security and Access Control etc. Performance Criteria for DCS and other automation tools. Selection and control of different process with advanced tools available with DCS, SCADA and PLCs. Discussion about hybrid control system. HART, Foundation fieldbus, Profibus protocol introduction, frame structure, programming, implementation examples, Benefits, Advantages and Limitations. Comparison with other fieldbus standards including device net, Profibus, Controlnet, CAN, Industrial Ethernet etc. Test and validation of system architecture, safety plans, and Safety Instrumented Systems (SIS).

Introduction to Functional Safety Standards: IEC 61508, IEC61511

Reference Books:

[1]	Popovic and Bhatkar , Distributed Computer Control For Industrial Automation, Taylor & Francis group, 2011.
[2]	Webb and Reis, Programmable Logic Controllers: Principles and Applications, PHI, 2009.
[3]	B. G. Liptak , “Process Control, Instrument Engineering Hand book”, Chilton Book Company, Third Edition, 1995
[4]	S. K. Singh, Computer Aided Process Control PHI, 2009.
[5]	KJ Kirkcaldy , D Chauhan - Functional Safety in the Process Industry: A Han Practical guidance in the Application of IEC61511 and ANSI/ISA-84

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Research Methodology and Intellectual Property Rights						
Course Code	SET-25001		**Examination Scheme**			
Teaching Scheme	2-1-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: --	ESE: -	-

Course Outcomes: Students will be able to:

1. Define research problem formulation and approaches of investigation of solutions for research problems.
2. Learn and use ethical practices to be followed in research and apply research methodology in case studies and acquire skills required for presentation of research outcomes.
3. Analyze IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario.
4. Summarize that it is an incentive for further research work and investment in R & D, leading to the creation of new and better products and generation of economic and social benefits.

Course Contents:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations.

Effective literature studies approaches, analysis, Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype, Analyze your results and draw conclusions or Build Prototype, Test and Redesign, Plagiarism, Research ethics, Effective technical writing, how to write report, Paper.

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Introduction to the concepts Property and Intellectual Property, Nature and Importance of Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights

Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and its Administration, Administration of Patent System – Patenting under Indian Patent Act, Patent Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non- Provisional Patent Application and Specification, Plant Patenting, Idea Patenting, Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies

New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development, International Scenario: WIPO, TRIPs, Patenting under PCT

Reference Books:

[1]	Aswani Kumar Bansal : Law of Trademarks in India
[2]	B L Wadehra : Law Relating to Patents, Trademarks, Copyright,Designs and Geographical Indications.
[3]	G.V.G Krishnamurthy : The Law of Trademarks, Copyright, Patents and Design.
[4]	Satyawrat Ponkse: The Management of Intellectual Property.
[5]	S K Roy Chaudhary & H K Saharay: The Law of Trademarks, Copyright, Patents
[6]	Intellectual Property Rights under WTO by T. Ramappa, S. Chand.
[7]	Manual of Patent Office Practice and Procedure

[8]	WIPO: WIPO Guide to Using Patent Information
[9]	Resisting Intellectual Property by Halbert,Taylor & Francis
[10]	Industrial Design by Mayall, Mc Graw Hill
[11]	Product Design by Niebel, Mc Graw Hill
[12]	Intellectual Property in New Technological Age by Robert P. Merges, Peter S. Menell, Mark A. Lemle
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Process Control and Applications						
Course Code	IAM(PE)-25003		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA:	MSE:	ESE:
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Know the application of different transducers, calculation of errors in measurement and computer process control systems.
2. To analyze various process characteristics and dynamics.
3. To implement various control configurations for industrial processes using advanced process control techniques.
4. Develop advanced control techniques, system identification and process modelling.

Course Contents :

Review of process characteristics and process analysis, Introduction of different control strategies for various processes. Process identification methods, Analysis, and control of some common processes like Distillation column, Boilers, Heat Exchangers, Spray Dryer and evaporator, Types of models and modeling methods, process dynamics and design, advanced and intelligent control strategies and their applications, RGA, Introduction to interaction and decoupling. Case study: Conventional and advanced control implementation for industrial applications

Reference Books:

[1]	S K Singh, Process Control Concepts, Dynamics and Applications, PHI Publications, 2009
[2]	Andrews and Williams, Principles of Applied instrumentation, Vol. I, II, III, IV, Gulf
[3]	Publications company
[4]	F. G. Shinsky, Process Control System, Mc Graw Hills, 1996.
[5]	B.G. Liptak, ―Process Control, Chilton Publications, Fourth edition, 2009.
[6]	Design and Application of Process Control Systems, ISA

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Embedded Systems						
Course Code	IAM(PE)-25004		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE:-	-

Course Outcomes: Students will be able to:

1. To understand the scientific principles and concepts behind small scale embedded systems.
2. To have direct hands-on experience on both hardware and software elements commonly used in small scale embedded system design.
3. To have knowledge of hardware/software co-design.
4. Understanding the applications and role of microcontrollers for embedded systems design.

Course Contents:

Embedded Systems:

Definition, classification, examples and broad overview. Embedded system design criterions, architectural design aspects, embedded programming and tools for building embedded systems, memory types- organization and interfacing. Small scale embedded system design: Architecture of small scale microcontroller (PIC18F4550), I/O programming, Interrupt driven programming, digital and analog sensor interfacing, actuator interfacing, Programming with: Timers, Counters, PWM, Enhanced PWM, CCP Module, On chip communication protocols: UART and USART (I2C, SPI).

Case studies and applications:

DC Motor control, Control of conveyer belt, etc. STM 32-bit microcontroller architecture—technology overview, Architectural Features: Block Diagram, CPU modes, register organization, ROM, RAM, timers, data and address bus, Memory and I/O interfacing concepts, memory mapped I/O. CISC Vs RISC design philosophy, pipelining, exceptions and its handling, memory, I/O‗s and addressing modes.

Reference Books:

[1]	Mazidi, PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC 18 series, Pearson, January 2008 edition.
[2]	John B. Peatman-- Design with PIC Microcontrollers, Pearson, 2009 Edition.
[3]	Raj Kamal, ―Embedded Systems – Architecture: Programming and Design, Tata McGraw-Hill Education, 3rd ed.,2003.
[4]	Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers, 2014, Jonathan W Valvano Create space publications ISBN: 978-1463590154.
[5]	Embedded Systems: Introduction to ARM Cortex – M Microcontrollers, 5th edition Jonathan W Valvano, Create space publications ISBN-13: 978-1477508992

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Industrial Networking Protocols and Standards						
Course Code	IAM(PE)-25001		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA:	MSE:	ESE:
Credits	3		**Laboratory**	CIE: -	ESE: -	--

Course Outcomes: Students will be able to:

1. Identify the need for network protocols during data exchange.
2. Demonstrate the use of serial standards as required in an industrial plant environment.
3. Demonstrate IOT networking for Field devices

Fundamental of Industrial Data Communication Systems:

Review of Data Acquisition, Automation System Architecture - Hierarchical Levels, Functional Layered Models - OSI reference model, System engineering approach, Input / Output Structures, Control Unit Structure, Protocols, Communication principles and modes: network topology, transmission media, noise, cable characteristic and selection; bridges, routers and gateways

Serial data communication interface standards, CSMA/CD, CA protocol, OSI implementation for Industrial communications, HART Communication Protocol Architecture - physical, data link, application layer, communication technique, normal and burst mode of communication, benefits of HART.

Industrial Ethernet:

10Mbps, 100Mbps Ethernet, Gigabit Ethernet, Industrial Ethernet.

Foundation fieldbus:

Fieldbus requirement, features, advantages, fieldbus components, types, architecture–physical, data link, application layer, system and network management, wiring

Basics of IoT Networking – Part I, Functional Components of IoT, IoT Service Oriented Architecture, IoT Gateways, IOT communication Protocol: UDP, MQTT, 6LoWPAN, Introducing Industry 4.0, IT/OT Convergence and Integration

Reference Books:

[1]	Bela Liptak, Process Software and Digital Networks, CRC Press
[2]	S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT, Cambridge University Press.

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Modern Control Theory						
Course Code	IAM(PE)-24002		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE:30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	--

Course Outcomes: Students will be able to:

1. Describe dynamics of a linear system by State Space Representation.
2. Analyze the controllability, Observability and stability of a linear system
3. Design controller and observer for a linear continuous time system.
4. Realize the structure of a discrete time system and model its action mathematically.

Course Contents:

State variable representation of linear and nonlinear systems, comparison with transfer function representation, standard forms of representation. Time and frequency domain specifications, Pole placement by state feedback, controllability and observability, design of observers, separation principle. Controller design using transfer function approach. Introduction to discrete time control, z transforms, difference equations, analysis of discrete time systems, controller design in discrete domain.

Reference Books:

[1]	K. Ogata, "Modern Control Engineering", Fourth Edition, Prentice Hall of India, 2002.
[2]	J. Nagrath and M. Gopal, "Control System Engineering", Second Edition, Wiley Eastern Limited.
[3]	M. Gopal, "Control Systems, Principles and Design", Second Edition, TMH, New Delhi, 2002. 4. B. C. Kuo, "Automatic Control Systems", Seventh Edition, Prentice Hall of India, New Delhi, 2002.
[4]	A. Nagoor Kani, Control System, RBA Publications.
[5]	M. Gopal , Digital Control & State Variable Methods, TMH.

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Robotics and Automation						
Course Code	IAM(PE)-25005		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	--

Course Outcomes: Students will be able to:

1. Perform kinematic and dynamic analyses with simulation.
2. Design control laws for a robot.
3. Integrate mechanical and electrical hardware for a real prototype of robotic device.
4. Select a robotic system for given application.

Introduction to Robotics:

Types and components of a robot, Classification of robots, closed-loop and open loop control systems. Kinematics systems; Basic definitions of Robotics, Descriptions: Positions, Orientations, Frames, Robot Anatomy – Links, Joints and Joint Notation scheme, Degrees of Freedom (DOF), mechanisms and manipulators, Required DOF in a Manipulator.

Robot Kinematics and Dynamics:

Kinematic Modeling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics, Dynamic Modeling: Equations of motion: Euler-Lagrange formulation

Robotic sensor:

Contact and Proximity, Position, Velocity, Force, Tactile, Force-Torque sensors and Robotic Vision.

Actuators:

Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators.

Robotics control:

Second order linear system, Feedback control laws: P, PD, PID, Non-linear trajectory tracking control, joint controller, Control Hardware and Interfacing with sensors, actuators, components, Robotic Programming (VAL II), Applications of Industrial robot (PUMA, KUKA, FANUC, MTAB).

Textbooks:

[1]	Ashitava Ghoshal, Robotics Fundamental Concepts & Analysis, Oxford University Press. (2006).
[2]	Mittal and Nagrath , Robotics and Control , Tata McGraw-Hill Publishing Company Ltd., New Delhi (2004)
[3]	Nikku, S.B., Introduction to Robotics, Prentice Hall of India Private Limited (2002).
[4]	Saha, S.K., "Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.

Reference Books:

[1]	Richard D. Klafter, Thomas A Chmielewski and Michael Negin, Robotics Engineering: An integrated approach, Prentice Hall. (1998)
[2]	John Craig , Introduction to Robotics, mechanics and control, Pearson Education, New Delhi. (2005)
[3]	M.P. Groover, Mitchell Weiss, Roger N. Nagel & Nicholas Godfrey, Industrial Robotics. Tata McGraw Hill Education Pvt. Ltd. (2001)
[4]	Gonzalex, R. C. and Fu, K. S., Robotics Control Sensing, Vision and Intelligence, McGrHill (1985).
[5]	Koren,Y., Robotics for Engineers, McGraw Hill (2004).

Note:

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Soft Computing						
Course Code	IAM(PE)-25006		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: --	--

Course Outcomes: Students will be able to:

1. Describe the role of soft computing techniques in real world
2. Recognize the feasibility of applying appropriate soft computing techniques for a given real world problem
3. Examine the solution of problem based on of the basics of learning and training algorithms
4. Develop engineering applications using neural network, fuzzy logic, genetic algorithm and hybrid system.

Introduction to Soft Computing

characteristics of Soft computing, Difference between Hard and Soft computing, Requirement of Soft computing, Basic tools of soft Computing – Fuzzy logic, Neural Networks and Evolutionary Computing , Applications of Soft Computing.

Introduction to Neural Network

Biological and Artificial Neuron, Neural Networks, Supervised and Unsupervised Learning. Single Layer Perceptron, Multilayer Perceptron, Backpropagation Learning, Neural Networks as Associative Memories, Hopfield Networks, Bidirectional Associative Memory, Topologically Organized Neural Networks, Competitive Learning, Kohonen Maps.

Introduction to Fuzzy Logic

Fuzzy Sets, Properties, Membership Functions, Fuzzy Operations, Fuzzy Inference System, Fuzzification and defuzzifications module, Scaling factors, Fuzzy controllers. Introduction to Genetic Algorithms, Introduction and concept, Coding, Reproduction, Cross Applications, Swarm intelligence, and their applications.
Evolutionary Computation, Overview of Bio-inspired Algorithms-Swarm Intelligence Algorithms, Particle Swarm optimization, Ant Colony optimization, Grey-Wolf optimization, Hybrid systems: Neuro-fuzzy, Genetic-neuro, Genetic-fuzzy.

Textbooks:

[1]	S. Rajasekaran and G. A. Vijayalakshmi Pai, “Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications”, 2nd Edition, PHI Learning, 2003.
[2]	Samir Roy and Udit Chakraborty “Soft Computing: Neuro-Fuzzy and Genetic Algorithms”, 1st Edition, Pearson, 2006.

Reference Books:

[1]	Dan W. Patterson, “Introduction to Artificial Intelligence and Expert Systems”, 3rd edition , Prentice-Hall International, 2000.
[2]	J. M. Zurada, “Introduction to Artificial Systems”, 5th Edition, Jaico Publishing House, 2004.
[3]	James A. Anderson, “An Introduction to Neural Networks”, 2nd edition, Prentice Hall of India, New Delhi, 1999.
[4]	D. Drainkov, H. Hellendoorn and M. Reinfrank, “An Introduction to Fuzzy Control”, 6th edition , Springer-Verlag Berlin Heidelberg Publisher, 2008.
[5]	T. J. Ross, “Fuzzy Logic with Engineering Applications”, 3rd edition, MIT Press, Inc 2011.
[6]	Kosko Bart, “Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence”, Prentice Hall of India, New Delhi, 2001.
[7]	Melanie Mitchell, “An Introduction to Genetic Algorithms”, 2nd Edition, MIT Press

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Sensors and Actuators						
Course Code	IAM(PE)-25002		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Understanding basic laws and phenomena on which operation of sensors and actuators transformation of energy.
2. Create analytical design and development solutions for sensors and actuators.
3. Know the basic laws of behaviour of sensors and actuators.
4. Able to know about the Standards for Smart Sensor Interface
5. Analyse the development and application of sensors and actuators.

Course Contents:

Introduction of sensor, transmitter, and transducer, Static and Dynamic characteristics Principle of operation, construction details, characteristics and applications of transducers Electrical, optical, Smart sensors etc., signal conditioning circuits.

Definition, types, and selection of Actuators; linear; rotary etc., Pneumatic, Electro-Pneumatic, Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria. Electrical actuating systems.

Micro Sensors and Micro Actuators::

Principles and examples, Types of micro actuatorsElectrostatic, Magnetic, Fluidic, Inverse piezo effect, other principles Materials for sensors: Silicon, Plastics, metals, ceramics, glasses, nano materials Processing techniques: Vacuum deposition, sputtering, chemical vapor deposition, electro plating, photolithography, silicon micro machining, Bulk silicon micro machining, Surface silicon micro machining, LIGA process

Textbooks:

[1]	Patranabis.D, “Sensors and Transducers”, Wheeler publisher, 1994.
[2]	Sergej Fatikow and Ulrich Rembold, “Microsystem Technology and Microbotics”, First edition, Springer –Verlag NEwyork, Inc, 1997.
[3]	Jacob Fraden, “Hand Book of Modern Sensors: Physics, Designs and Application” Fourth edition, Springer, 2010.

Reference Books:

[1]	Robert H Bishop, “The Mechatronics Hand Book”, CRC Press, 2002.
[2]	Thomas. G. Bekwith and Lewis Buck.N, Mechanical Measurements, Oxford and IBH publishing Co. Pvt. Ltd.,
[3]	Massood Tabib and Azar, “Microactuators Electrical, Magnetic, thermal, optical, mechanical, chemical and smart structures”, First edition, Kluwer academic publishers, Springer, 1997.

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Semester - II

Industrial Cyber Security						
Course Code	*IAM-25003*		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: 50	-

Course Outcomes: Students will be able to:

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

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, Wireless HART, ISA 100, Bluetooth, Zigbee, Safety and OT Security requirements as per IEC 61511 and IEC62443: No Safety without Security.

Understanding OT Network:

Understanding OT Network Attack Surface (Hardware to Cloud), Common OT Network Vulnerabilities, Understanding Cyber Kill Chain, Example Attack Demonstration
Understanding Attacks on OT Protocols: Attacks on Modbus, EtherNet/IP, PROFINET (Replay, scanning, enumeration, DOS, MiTM Attack, Crafting Discovery Packets using scapy, Fuzzing)

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)
Standards/Guidelines/Frameworks/Regulations – NIST, ISA/IEC 62443
OSINT for ICS, Understanding OT Visibility, Log Monitoring and Management, Risk Assessment and Risk Management, Understanding MITRE Attack Framework, Understanding Zero Trust Architecture, Summary and Closure

Reference Books:

[1]	Ronald L. Krutz, “Industrial Automation and Control System Security Principles: Protecting the Critical Infrastructure”, 2nd Edition, International Society of Automation, 2017.
[2]	David J. Teumim, “Industrial Network Security, Second Edition”, International Society of Automation, 2010.
[3]	Lawrence M. Thompson and Tim Shaw, “Industrial Data Communications”, Fifth Edition, International Society of Automation, 2015.
[4]	Dick Caro, “Automation Network Selection: A Reference Manual”, 3rd Edition, Paperback, International Society of Automation, 2016.
[5]	Abhirup Guha- “Implementing IEC 62443: Best Practices for OT Security

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Artificial Intelligence and Machine Learning						
Course Code	IAM-25004		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	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
4. Understanding the various models related to process control applications
5. Development of data-based controls for Process Control Applications

Artificial Intelligence (AI) Fundamentals:

defining AI techniques. 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. Supervised, unsupervised and semi-supervised learning, Algorithms. Concepts, instances and attributes, training and testing data, Libraries for ML. Gradient descent algorithm, cost function, Activation functions, data preprocessing and transformation techniques. Applications of ML to Process Control, Development of Models- Black-box, Gray box and white box models, model validations with physics based models, system identification. Development of Data based controls Data based Controls and ML based controls for Process Control Applications.

Text Books and Reference Books:

[1]	Tom Mitchell, "Machine Learning", McGraw-Hill, 1997
[2]	Ethem Alpaydin, "Introduction to Machine Learning", PHI, 2005
[3]	Bishop, C., "Pattern Recognition and Machine Learning:" Berlin: Springer-Verlag, 2006
[4]	K.P. Soman, R. Longonathan and V. Vijay, "Machine Learning with SVM and Other Kernel Methods", PHI
[5]	Christopher M. Bishop, "Pattern Recognition and Machine Learning

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Building Automation						
Course Code	IAM-25005		**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: 50	-

Course Outcomes: Students will be able to:

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

Course Contents:

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. Concept of Air handling unit. Design, working of different components in AHU- damper, filter, cooling coil, heating coil, fan, heat recovery wheel, humidifier. Chilled Water Systems: Working, mechanical configuration of different types of components used in refrigeration cycle- evaporator, condenser, compressor, expansion valve. 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.

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. Concept of automation in access control system for safety. Physical security system with components, RFID enabled access control with components. Open Protocols -BACnet, LON, Profibus, Modbus, M-bus, Proprietary Protocols. Different fire sensors, smoke detectors and their types. CO and CO2 sensors. Fire control panels. Design considerations for the FA system.

Reference Books:

[1]	Roger W. Haines “HVAC Systems Design Handbook”, Fifth Edition
[2]	James E. Brumbaugh “HVAC Fundamentals”, volume 1 to 3
[3]	Fundamentals Of Refrigeration”, Indian Society of Heating, Refrigerating & Air Conditioning Engineers

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Advanced Control System						
Course Code	AM(PE)-25007		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Formulate and design the sliding mode controller for an application at hand
2. Understand the need for special sliding mode controllers and its design
3. Design the discrete time sliding mode controllers
4. Understand and synthesis the stable higher order sliding mode controllers

Course Contents

Nonlinear control preliminaries, Types of Uncertainty-Matched and Unmatched uncertainties effect of disturbances, Concept of variable structure control, Sliding Mode Control, properties of SMC, reachability condition, reaching laws, computation of equivalent control, chattering phenomenon, Lyapunov stability theory.

Discrete sliding mode control, Reaching law for discrete-time sliding mode (DSM), DSM for matched and unmatched uncertainties, DSM using multirate technique, Finite time and terminal sliding mode, Sliding mode observer, Integral sliding mode, Integral sliding mode with nonlinear composite feedback control (CNF),

Higher Order Sliding Modes: Concept of relative degree- Order of sliding mode- New features in HOSM- Twisting and Supertwisting algorithms- Majorant curve and Lyapunov proofs- Design Examples.

Reference Books:

[1]	C. Edwards and S.K. Spurgeon, ―Sliding Mode Control: Theory and Applications‖, Taylor & Francis, 1998.
[2]	G. Bartolini, L.Fridman, A. Pisano and E. Usai (Ed.), ―Modern sliding mode control theory‖, Springer, 2008..
[3]	J.J.E Slotine and W. Li, ―Applied nonlinear control‖, Prentice Hall, 1991.
[4]	Y. Shtessel, C. Edwards, L. Fridman, A. Levant, Sliding Mode Control and Observation, 1st Edition, Springer Birkhauser, 2014.
[5]	Bandyopadhyay B. and Janardhanan S., Discrete-time Sliding Mode Control: A Multirate Output Feedback Approach, 1st Ed., Springer. 2006.
[6]	Utkin V., Guldner J. and Shi J., Sliding Mode Control in Electromechanical Systems2nd Edition., Taylor and Francis, 2009.
[7]	B. Bandyopadhyay, Fulwani Deepak, Kyung-Soo Kim, Sliding mode control using novel sliding surfaces "1st Edition, Springer, 2009.
[8]	L. Fridman, J-P Barbot, Frank Plestan, Recent Trends in Sliding Mode Control, 1st Edition, IET Publisher, 2016.

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Mechanics and Control of Robotic Manipulator						
Course Code	IAM(PE)-25008		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: --	ESE: --	--

Course Outcomes: Students will be able to:

1. Learn algorithmic approaches, mathematical models, and computational and motion control methods applicable to robotic manipulator systems
2. Recognize and analyze the basic mechanical and electrical systems concerning robots
3. Analyze and design the basic robotic systems
4. Implement and investigate the performance of various control techniques to the robotic manipulators

Introduction to robotic manipulator:

Effector: locomotion, and manipulation. Serial and parallel manipulators. Descriptions, Transformations and homogeneous transformation matrix. Manipulator (serial manipulator)

Kinematics:

Kinematic parameters, different notations, Denavit-Hartenberg (DH) representation, arm matrix. Forward and inverse kinematics. Analytical and numerical solutions.

Differential kinematics:

Differential (velocity) kinematics, velocity propagation, forward differential kinematics and inverse differential kinematics. Jacobian matrix and Manipulator statics: Mapping between configuration-space to operational-space. Jacobian matrix and Pseudo inverse concepts. Introduction to workspace singularities.

Manipulator statics:

Conservation of energy or power, the mapping between operation-space to configuration-space inputs. Manipulator dynamics: Motion dynamics: Forward and inverse dynamics. Lagrangian (Lagrange-Euler) and Newton-Euler formulations. Dynamic simulation: Dynamic modeling of robotic manipulators and computer-based numerical simulations

Trajectory generation:

Path and Trajectory. Configuration (joint) space trajectory and operational (task) space trajectory generations. Control of robotic manipulators: Joint space and task-space control schemes.

Reference Books:

[1]	SK Saha, Introduction to Robotics, Tata McGraw-Hill, 2014, ISBN: 9789332902817
[2]	A Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2008, ISBN: 9780195673913
[3]	JJ Craig, Introduction to Robotics: Mechanics and Control, John Wiley and Sons, 2004, ISBN: 9780201543612
[4]	RM Murray, Z Li, SS Sastry, A Mathematical Introduction to Robotic Manipulation, CRC Press, 1994, ISBN: 9780849379819
[5]	RN Jazar, Theory of Applied Robotics: Kinematics, Dynamics and Control, Springer, 2010, ISBN: 9781489977602

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Process Modeling and Optimization						
Course Code	AM(PE)-25009		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Understanding of process model design using first principles, conversation principles and process data.
2. Have an understanding of computational techniques to solve the process models.
3. To solve and analyze optimization problem formulations.
4. Get familiar with analytical techniques used to solve single objective, unconstrained and constrained optimization problems.

Introduction of Mathematical Modeling:

Definition of process Model, Physical and Mathematical modeling, deterministic and stochastic models, need of models and their classifications, model building, black-box model. Classification and use of mathematical models, principles of formulation, fundamental laws Case study: CSTR Model, boiler-heat exchanger model.

Model Solving:

Solving non-linear simultaneous equations using Newton‘s Method. Introduction to various simulation software and solvers. Optimization Fundamentals: Optimization problems, objective function, constraint and unconstraint surfaces, classification of optimization problems. Convexity and concavity of functions having one and two variables.

Unconstrained Optimization:

Optimization of a function with one and multiple variables, gradient vectors, subject to equality constraints and Lagrangian multipliers, Hessian matrix formulation, necessary and sufficient conditions of optimality (KKT) conditions.

Linear Programming:

Standard form of linear programming problem, canonical form of LP problem, Simplex method, simplex algorithm, construction of simplex tableau, minimization versus maximization problem. Constrained optimization: formulation of equality constraint and inequality constraint optimization problems, KKT conditions, Lagrangian methods, NLP and solution of NLP by sequential quadratic programming (SQP) methods.

Reference Books:

[1]	Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", 2nd Ed., McGraw Hill
[2]	Edger, Himmelblau, Lasdon, Optimization of Chemical Processes,McGraw-Hill International, Edition
[3]	S.S. Rao, "Engineering Optimization: Theory and Practice", New Age International P)Ltd., New Delhi.
[4]	K. Deb, "Optimization for Engineering Design-Algorithms and Examples", Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.
[5]	Denn M. M., "Process Modeling", Longman, 1986
[6]	B Wayne Bequette, Process Dynamics: Modelling, Analysis and Simulation, Prentice Hall International Inc.

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Advanced Digital Signal Processing						
Course Code	IAM(PE)-25011		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Know the analysis of discrete time signals.
2. Study the modern digital signal processing algorithms and applications.
3. Use of in-depth knowledge of digital systems in real time applications
4. Apply the algorithms for wide area of recent applications**.**

Introduction to ADSP:

Revision of various transform. Multirate digital Signal Processing –Interpolation, Decimation, Sampling rate conversion by non-integer factor, Multistage Interpolation and Decimation, Digital filter banks, application of multirate DSP.

Discrete time Random processes:

Random variables Discrete time random processes, Random variable ensemble averages, jointly distributed random variables, Independent uncorrelated and Orthogonal Random variables, linear mean square estimation, The autocovariance and Autocorrelation Matrices, Autoregressive moving average processes, Power spectrum estimation – non parametric power spectrum estimation, the periodogram, performance of periodogram, Bartletts method, Welch's method, parametric power spectrum estimation, Auto regressive spectrum estimation, Model parameters Yule Walker equation, Moving average spectrum estimation.

Linear prediction and optimum linear filters:

Forward linear prediction, solution of normal equation Levinson Durlin algorithm, Wiener filters for filtering and prediction, FIR Wiener filter, orthogonality principle in linear mean square estimation.

Adaptive filters:

Adaptive filtering system identification, FIR Adaptive filters, The steepest descent Adaptive filter, LMS algorithm, convergence of the LMS algorithm, Normalized LMS algorithm, Noise cancellation, Channel equalization, recursive least square algorithm. Applications of ADSP.

Textbooks:

[1] Digital Signal Processing Principles, Algorithms, and Applications by John G. Proakis, Prentice-Hall International Inc., 4th Edition, 2012.

[2] Theory and Application of Digital Signal Processing by Lawrence R. Rabiner and Bernard Gold.

Reference Books:

[1] Oppenheim, Alan V. Discrete-time signal processing. Pearson Education India, 1999. Mitra, Sanjit Kumar, and Yonghong Kuo. Digital signal processing: a computer-based approach. Vol. New York: McGraw-Hill Higher Education, 2006.

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Batch Process Control						
Course Code	IAM(PE)-25012		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Study different standards required for batch process control.
2. Identify and understand different modules and components in batch Standards.
3. Discuss different configuration of batch system to enhance the availability of process.
4. Implement the standards for different batch processes with latest technology

Course Contents:

Introduction to Batch Control System, Batch Control system terminology, Characteristics of Batch Processes, Hierarchical Batch Model, Control structure for batch systems. International Standards and Practices such as S 88, S 95, USA FDA regulation, 21CFR 11, etc. regulatory and discrete systems, Batch control design, system hardware and software, Batch control system specifications and implementation, Information/display requirements, cost justification and benefits, data management. Case study of batch control system implementation for applications in food and beverages, pharmaceuticals, etc.

Reference Books:

[1]	T. G. Fisher, ―Batch Control System, ISA series, 2nd Edition, 2010.
[2]	B. G. Liptak , "Process Control, Instrument Engineering Hand book", Chilton Book Company, Third Edition, 1995
[3]	Gregory K. Macmillan, Process/ Industrial Instruments and Controls Handbook, MCGrawHill

Note:

[1]	To measure CO1, questions may be of the type- define, identify, state, match, list, name etc.
[2]	To measure CO2, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.
[3]	To measure CO3, questions will be based on applications of core concepts.
[4]	To measure CO4, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.
[5]	To measure CO5, some questions may be based on self-study topics and comprehension of unseen passages.

Industrial Drives and Control						
Course Code	IAM(PE)-25013		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE: -	-

Course Outcomes: Students will be able to:

1. Design single and three phase rectifiers and dc-dc / ac-dc converters.
2. Apply the control aspects for designing controllers for converters.
3. Select appropriate motor and its drives for real life applications.
4. Compare and critically evaluate motor characteristics for various real-life applications.

Power Semiconductor Devices:

Introduction, Scope and Application, Classification of Power Converters, Construction and characteristics of Thyristors, MOSFET, IGBT, IGCT and GTO, Comparison of Controllable switches.

Phase Controlled (AC to DC) Converters (Rectifiers):

Principle of phase control, Full wave-controlled Converters. Single phase full wave converters, Single phase two pulse converters with discontinuous load and its performance, three phase thyristor converters: half wave, full and semi converters. Dual Converters. Effect of source impedance on performance of converter.

DC to DC Converters (Choppers):

Introduction, Classification, Principle and Operation, Control strategies, Chopper configurations, Thyristor chopper circuits, Jones chopper, Morgan chopper, AC (Multiphase) chopper, switched mode power supply: step down (buck), Step up (boost) and step down/step up (buck/boost) converters and Cuk converter.

DC to AC Converters (INVERTERS):

Introduction, Classification, single phase half and full bridge VSI, three phase VSI 120 and 180 degree conduction mode. Performance Parameters of Inverter, Voltage control of single phase and three phase Inverter, Series inverter, Parallel inverter, Current source inverter.

AC Voltage Controllers:

Introduction, Principal of On-Off control and Phase Control, Single phase Bidirectional Controllers with R and R-L Loads, three full phase wave controllers

Cycloconverters:

Single Phase and Three phase Cycloconverter and Matrix Converter

Application of Power Electronics:

D.C. Motor Speed control, A.C. Drives: variable frequency drives. AC Voltage Regulators.

Textbooks:

[1]	Ned Mohan, Tore M. Undeland, 'Power electronics: converters, applications, and design', John Wiley &Sons.
[2]	P. S. Bimbhra, "Power Electronics", Khanna Publishers, New Delhi.
[3]	M.D. Singh, K B Khanchandani, 'Power Electronics', second edition, TATA McGraw Hill.

Reference Books:

[1]	Muhammad H. Rashid, "Power Electronics - circuits, devices and applications", Prentice Hall of India.
[2]	Power Electronics – Devices, Converters and Applications", by Vedam, New Age Publications.
[3]	Thyristorised controller by Dubey, Joshi & Doradla, New age Publication.
[4]	B. K. Bose, 'Modern Power Electronics & AC Drives', Prentice Hall India

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Industrial Internet of Things						
Course Code	IAM(PE)-25014		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: -	ESE:-	-

Course Outcomes: Students will be able to:

1. Understand, design and develop the real life IoT applications using off the shelf hardware and software.
2. Knowledge of Key components in the field of IIoT, Architectures and its pros and cons
3. Interpret the various IoT Layers and their relative importance in Business Models.
4. Use various IoT platforms and security for solving social and industrial problems.

Introduction to IIoT&IIoT Architectures

Overview of Components of IIoT – Sensors, Networks, Characteristic of IIoT System, Architectures for IIoT, Types of Architectures, Components of IIoT – Field Devices (Sensors /Actuators) & Field Networks - Sensors, Applicability of Sensors in different Industries, Design of sensors, Special requirements for IIoT sensors, Sensor architecture, Actuators basics, Types of Actuators, Introduction to wired and wireless technologies, Topologies of Networks, Overview of Protocols such as ZIGBEE, ZWAVE, MBUS, etc. Different IIoT networks & connectivity, Modes of communications, Overview of various IIoT protocols like - COAP, 6LoWPAN, LWM2M, MQTT, AMPQ etc., Comparison of Industrial devices vs. Prototype devices (Arduino, Mega, Pi, Galileo), Software Architecture of Edge/FOG devices. IOT Platform Architecture, Overview & Understanding of of COTS cloud platforms like Predix, Watson, Thingworks, Azure etc. , Basic understanding of various business models like SaaS, PaaS&IaaS and pros & cons IoT Privacy, Security & Governance - Security Basics - Risk, Threat & Vulnerability, Risk Assessment, IIoT Security Framework based on IIC , Basic understanding of various IIoT security standards like NIST 82, IEC 62443, NERC, NIC etc., Hardware based Security, Overview of Data analytics, Cloud services, IIoT Use cases& Recent Trends in IOT - Data Analytics Basics, various techniques – Machine Learning , Deep learning, AI, Overview of IOT Cloud Services, classification and machine learning algorithms extract useful information from aggregated data, Recent Trends in IIOTs

Reference Books:

[1]	Industrial Internet Vocabulary - IIC
[2]	The Industrial Internet of Things Volume G1: Reference Architecture – IIC
[3]	Industrial Internet of Things Volume G4: Security Framework – IIC
[4]	The Industrial Internet of Things, Volume B01: Business Strategy and Innovation Framework – IIC
[5]	Industrial Analytics: The Engine Driving the IIoT Revolution
[6]	Karen Rose, Scott Eldridge, Lyman Chapin, ―The Internet of Things: An Overview Understanding the Issues and Challenges of a More Connected World Internet Society
[7]	Bahga – Madisetti, ―Internet of things Book – A hands on Approach
[8]	Olivier Hersent, ―The Internet of Things: Key Applications and Protocols‖, 2nd Edition

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Semester - III

Dissertation Phase – I						
Course Code			**Examination Scheme**			
Teaching Scheme	0-0-22-12		**Theory**	TA:	MSE:	ESE: 100
Credits	20		**Laboratory**	CIE:	ESE: 50	--

Course Outcomes: Students will be able to:

1. Ability to synthesize knowledge and skills previously gained and applied to an in depth study and execution of new technical problem. [PEO1][PO1]
2. Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design and justify their design. [PEO3][PO6]
3. Ability to present the findings of their technical solution in a written report. [PEO2],[PO2].
4. Demonstrate an ability to present and defend their research work to a panel of experts. [PEO1],[PO3].

Dissertation-I:

The dissertation/ project topic should be selected/ chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study.

The dissertation should have the following:

1. Relevance to social needs of society
2. Relevance to value addition to existing facilities in the institute
3. Relevance to industry need /requirement
4. Problems of national importance
5. Research and development in various domain

The student should complete the following:

1. Literature survey
2. Problem Definition
3. Motivation for study and Objectives
4. Preliminary design / feasibility / modular approaches
5. Implementation and Verification
6. Report and presentation

Note:

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Semester - IV

Dissertation Phase II						
Course Code			**Examination Scheme**			
Teaching Scheme	0-0-22-12		**Theory**	TA: 20	MSE: 30	ESE: 100
Credits	11		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Ability to synthesize knowledge and skills previously gained and applied to an in depth study and execution of new technical problem. [PEO1][PO1]
2. Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design and justify their design. [PEO3][PO6]
3. Ability to present the findings of their technical solution in a written report. [PEO2],[PO2].
4. Demonstrate an ability to present and defend their research work to a panel of experts. [PEO1],[PO3].

The dissertation stage II

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them.

It may be based on:

1. Entirely on study and analysis of typical Instrumentation and Control system, Biomedical Instrumentation / devices / instruments / related to pic
2. Experimental verification / Proof of concept
3. Design, fabrication, testing, and calibration of an instrumentation system.
4. The viva-voce examination will be based on the above report and work.

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