COEP Technological University Pune

(A Unitary Public University of Govt. of Maharashtra)

School of Electrical and Communication Engineering

Curriculum Structure & Detailed Syllabus

M. Tech. (Automation)
Instrumentation and Control Engineering

(Effective from: A.Y. 2024-25)

M. Tech. (Automation) in
Department of Instrumentation and Control Engineering

Semester -I

Sr. No.	Course Code	Course Type	Course Title	L	T	P	S	Cr
01	IA19001	PSMC	Probability and Statistics	3	0	0	1	3
02	IA19002	PCC	Sensors and Actuators	3	0	0	1	3
03	IA19003	PSBC	Industrial Automation	3	0	0	1	3
04	IA19004	LC	Probability and Statistics*	0	0	2	0	1
05	IA19005	LC	Sensors and Actuators*	0	0	2	0	1
06	IA19006	LC	Industrial Automation*	0	0	2	0	1
07	IA(DE)-19001	DEC	Elective-I	3	0	0	0	3
08	IA(DE)-19002	DEC	Elective-II	3	0	0	0	3
09	MLC-19010	MLC	Seminar and Technical Writing	0	1	2	0	2
10	IA19007	PSBC	Modelling and Simulation Laboratory	0	1	2	0	2
11	MLC-19011	MLC	Research Methodology and IPR	0	0	0	0	0
							Total	**22**

Elective-I

1. Process Control and Applications
2. Embedded Systems
3. Instrument Design Engineering
4. Batch Process Control

Elective-II

1. Modern Control Theory
2. Cyber Security in Industrial Automation
3. Robotics and Automation
4. Soft Computing

Note:

*Experiments of the Laboratory course shall be based on the course contents of subject courses. The lab work shall consist of hands on experiments on the different software and hardware platforms related to the syllabus. Students are expected to perform **minimum ten experiments** based on above course contents.

Semester –II

Sr. No.	Course Code	Course Type	Course Title	L	T	P	S	Cr
01	OE-19001	OE	Open Elective	3	0	0	0	3
02	IA19008	PCC	Industrial Drives and Control	3	0	0	1	3
03	IA19009	PCC	Artificial Intelligence and Machine Learning	3	0	0	1	3
04	IA19010	PCC	Building Automation	3	0	0	1	3
05	IA19011	LC	Industrial Drives and Control*	0	0	2	0	1
06	IA19012	LC	Artificial Intelligence and Machine Learning*	0	0	2	0	1
07	IA19013	LC	Building Automation*	0	0	2	0	1
08	IA(DE)-19003	DEC	Elective-III	3	0	0	0	3
09	IA(DE)-19004	DEC	Elective-IV	3	0	0	0	3
10	lLC-19012	LLC	Liberal Learning Course	1	0	0	0	1
							Total	**22**

Elective-III and IV

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

Note:

*Experiments of the Laboratory course shall be based on the course contents of subject courses. The lab work shall consist of hands on experiments on the different software and hardware platforms related to the syllabus. Students are expected to perform **minimum ten experiments** based on above course contents.

Semester -III

Sr. No.	Course Code	Course Type	Course Title	L	T	P	S	Cr
01	OC-2001	SLC	Massive Open Online Course-I	3	0	0	0	3
02	IA-20001	SBC	Dissertation Phase-I			18	0	9
							Total	**12**

Semester -IV

Sr. No.	Course Code	Course Type	Course Title	L	T	P	S	Cr
01	OC-2002	SLC	Massive Open Online Course-II	3	0	0	0	3
02	IA-20002	SBC	Dissertation Phase-II			18		9
							Total	**12**

Probability and Statistics

Teaching Scheme:
Lectures: 3 hours / week

Examination Scheme:
Test 1: 20 Marks
Test 2: 20 Marks
End-Sem Exam: 60 Marks:

Course Outcomes

- **Acquaintance** with various methods of collecting data and get familiar with some elementary methods of data viz. Measures of central tendency, dispersion, skewness and kurtosis and to interpret them.
- **Understanding** the basic concepts of probability and to find probabilities of various events.
- **Understand** types of random variables, concepts of conditional probability and ability to distinguish between univariate and bivariate probability distributions; transformation of continuous random variable and its application.
- **Knowledge** of characteristics of random variables such as expectation, variance and also to compute various generating functions.

Course Contents

Sets, Classes, Collections, Sequence of Sets, Sigma-Ring, Sigma-Field, Monotone Class, Random Experiment, Events, Definitions of Probability, Properties of Probability Function, Conditional Probability, Independence of Events, Random Variables, Probability Distribution of a Random Variable, Moments, Characteristics of Distributions, Special Discrete Distributions, Poisson Process, Special Continuous Distributions, Normal Distribution, Function of a Random Variable, Joint Distributions, Independence, Product Moments, Linearity Property of Correlation and Examples, Bivariate Normal Distribution, Additive Properties of Distributions, Transformation of Random Variables, Distribution of Order Statistics, Chi-Square Distribution, t-Distribution, F-Distribution

Descriptive Statistics, Introduction to Estimation, Unbiased and Consistent Estimators, LSE, MME, Examples on MME, MLE, MSE, UMVUE, Sufficiency, Completeness, Rao-Blackwell Theorem and its Applications, Confidence Intervals, Types of Errors, Neyman-Pearson Fundamental Lemma, Applications of N-P Lemma, Testing for Normal Mean, Testing for Normal Variance, Large Sample Test for Variance, Paired t-Test, Testing Equality of Proportions, Univariate statistical plots and usage, Bivariate and multivariate statistics, linear regression, ANOVA

Text Books:

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. W.W. Hines, D.C. Montgomery, D.M. Goldsman, C.M. Borror, " Probability and Statistics in Engineering" John Wiley & Sons; 4th edition

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

Sensors and Actuators

Teaching Scheme
Lectures: 3hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

- Understanding basic laws and phenomena on which operation of sensors and actuators-transformation of energy.
- Create analytical design and development solutions for sensors and actuators.
- Know the basic laws of behaviour of sensors and actuators.
- Able to know about the Standards for Smart Sensor Interface
- 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: Principles and examples, and Micro Actuators: Types of micro actuators-Electrostatic, 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.

Text Books:

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.
4. Manfred Kohl, "Shape Memory Actuators", first edition, Springer.

Industrial Automation

Teaching Scheme
Lectures: 3hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

- **Apply** the knowledge of automation in the field of industrial process control.
- **Design** the plant-wide architecture of the control system for a process industry.
- **Develop** network architecture and detailed specifications of network components.
- **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. 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).

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. S.K.Singh, —Computer Aided Process Control‖, PHI, 2009.

Process Control and Applications

Teaching Scheme
Lectures: 3hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

- **Know** the application of different transducers, calculation of errors in measurement and computer process control systems.
- To **analyze** various process characteristics and dynamics.
- To **implement** various control configurations for industrial processes using advanced process control techniques.
- **Develop** the 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 Publications company
3. F. G. Shinsky, —Process Control System, Mc Graw Hills, 1996.
4. B.G. Liptak , —Process Control, Chilton Publications, Fourth edition, 2009.
5. Design and Application of Process Control Systems, ISA

Embedded Systems

Teaching Scheme
Lectures: 3hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

- To **understand** the scientific principles and concepts behind small scale embedded systems.
- To have a direct hands-on experience on both hardware and software elements commonly used in small scale embedded system design.
- To have **knowledge** of hardware/software co-design.
- **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$_{\pm}$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

Building Automation

Teaching Scheme
Lectures: 3hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

- **Identify** the components and understand basics of Building Automation System.
- **Design and implement** HVAC system controls
- **Demonstrate and explain** HVAC, Access Control and Fire Alarm System
- **Devise and select** components and equipment used in these systems.
- **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

Batch Process Control

Teaching Scheme
Lectures: 3hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

1. **Study** different standards required for batch process control.
2. **Identify and understand** different module 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:

- T. G. Fisher, —Batch Control System‖, ISA series, 2nd Edition, 2010.
- Gregory K. Macmillan, Process/ Industrial Instruments and Controls Handbook, MCGrawHill

Modern Control Theory

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

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.

Cyber Security in Industrial Automation

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

- 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.

Course Content

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

Messaging, Wireless HART, ISA 100, Bluetooth, Zigbee. 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

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.

Robotics and Automation

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

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.

Course Contents

Introduction to Robotics: Types and components of a robot, Classification of robots, closed-loop and open loop control systems, dynamics and kinematics of robotic systems; Definition of mechanisms and manipulators, Social issues and safety. Robot Kinematics and Dynamics: Kinematic Modelling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics, Dynamic Modelling: Equations of motion based Euler-Lagrange formulation Sensors and Vision System: Sensor: Contact and Proximity, Position, Velocity, Force, Tactile etc. Introduction to Cameras, Camera calibration, Geometry of Image formation, Euclidean/ Similarity/ Affine/ Projective transformations, Vision applications in robotics. Robot Control: Basics of control: Transfer functions, Control laws: P, PD, PID, Non-linear and advanced controls, Robot Actuation Systems, Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators. Control Hardware and Interfacing: Embedded systems, Architecture and integration with sensors, actuators, components, Programming for Robot Applications.

Text Books

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

Reference Books

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

Soft Computing

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes

- **Describe** the role of soft computing techniques in real world [PEO-1,3][PO-1,5]
- **Recognize** the feasibility of applying appropriate soft computing techniques for a given real world problem [PEO-3][PO-4,5]
- **Examine** the solution of problem based on of the basics of learning and training algorithms [PEO-2][PO-2, 3]
- **Develop** engineering applications using neural network, fuzzy logic, genetic algorithm and hybrid system.[PEO-2, 3][PO-3, 4]

Course Contents

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

Text Books

- S. Rajasekaran and G. A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic, and Genetic

Algorithms: Synthesis and Applications", 2nd Edition, PHI Learning, 2003.
- Samir Roy and Udit Chakraborty "Soft Computing: Neuro-Fuzzy and Genetic Algorithms", 1st Edition, Pearson, 2006.

Reference Books

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

Seminar and Technical Writing

Teaching Scheme
Tutorial: 1 hr/week
Practical's: 2hrs./week

Examination Scheme
Continuous Evaluation 50 Marks
Practical/ Oral Exam 50 Marks

Course Outcomes:

- **Interpretation** and **Solution** of real life engineering problems by applying knowledge.
- **Analyze** alternative approaches, apply and use most appropriate one for feasible solution
- **Present** seminar and **Write** precise technical reports in a nutshell.
- **Participates** effectively in multi-disciplinary and heterogeneous teams exhibiting team work, Inter-personal relationships, conflict management and leadership quality.

Course Contents

Modes of Technical Writings: Reports, Technical papers, book chapters, Manuals, Posters. Structure of a technical document. Copyright issues in technical writing: existing laws, open sources, permission procedure. How to write a good technical paper?, Proper procedure in citing already published works, Referencing styles. Common mistakes of English in scientific documents. Proper way of writing and citing equations. Proper use of figures and tables. Writing a good review paper. Writing of abstract, synopsis, cover letters, responses, discussion and keywords. Making title page, writing mathematical equations, including graphics, making tables and writing references using LaTex/ MiKTeX.

Project Based Seminar (PBS) helped students to gather, organize, summarize and interpret technical literature with the purpose of formulating a project proposal in final year. Students had also submitted a technical report summarizing state-of-the-art on an identified domain and topic. The student project work can be application oriented and/or will be based on some innovative/ theoretical and practical work. The student is expected to submit the seminar presentation and report in standard format approved by the internal evaluation committee. The topic for the seminar should essentially base on project work and relevant to the latest trends in

Instrumentation and Control. The project will be undertaken preferably by a group of 2-3 students who will jointly work and implement the project. The group will select a project which is based on seminar delivered in the relevant domain. Students should submit technical seminar report using LaTex/MikTeX.

Modeling and Simulation Laboratory

Teaching Scheme
Tutorial : 1 hrs./week
Practical : 2 hrs./week

Examination Scheme
Phase I and II Evaluation: 50 Marks

Course outcomes

- Understand the techniques of modeling in the context of hierarchy of knowledge about a system and develop the capability to apply the same to study systems through available software.
- Develop different types of simulation techniques.
- Simulate and analyze the models for the purpose of optimum control by using software.

Course Contents:

Introduction: System, environment, input and output variables, State variables; Static and Dynamic systems; Hierarchy of knowledge about a system and Modeling Strategy. Physical Modeling: Dimensions analysis, Dimensionless grouping of input and output variables of find empirical relations, similarity criteria and their application to physical models. Modeling of System with Known Structure: Review of conservation laws and the governing equation for heat, mass and momentum transfer, Deterministic model-(a) distributed parameter models in terms of partial identification and their solutions and (b) lumped parameter models in terms of differential and difference equations, state space model, transfer functions block diagram and sub systems, stability of transfer functions, modeling for control. Simulation of Engineering Systems: Monte-Carlo simulation, Simulation of continuous and discrete processes with suitable examples from engineering problems.

Modeling and Simulation has become an essential tool for engineers for optimum design and the Lab course aims to impart an overview of the modeling and simulation approaches with emphasis on applications using MATLAB. Students are expected to perform **minimum ten experiments** based on above course contents.

Research Methodology and Intellectual Property Rights

Teaching Scheme:
Lectures: 2hrs/week

Examination Scheme:
Continuous evaluation Assignments/Presentation/Quiz/Test

Course Outcomes

1. Define research problem formulation and approaches of investigation of solutions for research problems. [PEO1],[PO4].
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. [PEO2],[PO2].
3. Analyze IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario. [PEO2],[PO5].
4. Summarize that it is an incentive for further research work and investment in R & D, leading to creation of new and better products and generation of economic and social benefits.

[PEO3],[PO6].

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:

- Aswani Kumar Bansal: Law of Trademarks in India
- B L Wadehra : Law Relating to Patents, Trademarks, Copyright,Designs and Geographical Indications.
- G.V.G Krishnamurthy: The Law of Trademarks, Copyright, Patents andDesign.
- SatyawratPonkse: The Management of Intellectual Property.
- S K Roy Chaudhary & H K Saharay : The Law of Trademarks, Copyright, Patents

- Intellectual Property Rights under WTO by T. Ramappa, S. Chand.
- Manual of Patent Office Practice and Procedure
- WIPO : WIPO Guide To Using Patent Information
- Resisting Intellectual Property by Halbert ,Taylor& Francis
- Industrial Design by Mayall, Mc Graw Hill
- Product Design by Niebel, Mc Graw Hill
- Introduction to Design by Asimov, Prentice Hall
- Intellectual Property in New Technological Age by Robert P. Merges, Peter S. Menell, Mark A. Lemle

Industrial Drives and Control

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course outcomes

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.

Controlled Rectifiers: Single phase and three phase-controlled rectifiers. DC-DC converter: Isolated and non-isolated dc -dc converters, PWM control and design of r dc-dc converters. AC-DC Converters: AC-DC converter design, design of the converter controller for AC-DC Motor, AC and DC motors: DC motor drives, induction motor drives, synchronous motor drives and motor control.

Reference Books

1. "Fundamentals of Industrial Drives", B. N. Sarkar, PHI publication
2. "Power Electronics: Converters, application and design", Ned Mohan; Tore M. Undeland; William P Robbins, John Wiley & Sons publication.

Artificial Intelligence and Machine Learning

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course outcomes

- Understand Artificial Intelligence and its approaches.
- Solving some problems using supervised, unsupervised and semi supervised machine learning algorithm.
- Study of probabilistic analysis, parametric and non-parametric algorithms.
- Estimation of Maximum Likelihood, losses and risks for classifications problems.

Course Contents:

Artificial Intelligence - Introduction, Intelligent Agents, Problem-solving, Solving Problems by Searching, Informed Search and Exploration, Constraint Satisfaction Problems, Adversarial Search,

Knowledge and reasoning, Logical Agents, First-Order Logic, Inference in First-Order Logic, Knowledge Representation. Planning, Planning and Acting in the Real World, Uncertain knowledge and reasoning, Uncertainty, Probabilistic Reasoning, Probabilistic Reasoning over Time, Making Simple Decisions, Making Complex Decisions. Introduction to Machine Learning: What is machine learning, Applications of ML, Design Perspective and Issues in ML, Supervised, Unsupervised, Semi-supervised learning with applications and issues, Input : Concepts, instances and attributes, Output: Knowledge Representation: Decision tables, Decision trees, Decision rules, Rules involving relations, Instance-based representation, Data Pre- processing-data cleaning, data integration and transformation, data reduction, data discretization and concept hierarchy generation. Introduction to Classification, issues regarding classification, Classification:Model(or hypothesis) representation, decision boundary, cost function, gradient descent, regularization. Diagnostic: debugging a learning algorithm, evaluating a hypothesis (Modelselection), training/validating/testing procedures, diagnosing bias versus variance and vice versa, regularization and bias/variance, learning curves. Accuracy and Error measures: classifier accuracy measures, predictor error measure, evaluating the accuracy of a classifier or predictor, Confusion metric, precision, recall, tradeoff between both, accuracy. Decision Tree : representation, hypothesis, issues in Decision Tree Learning, Pruning, Rule extraction from Tree, Learning rules from Data, Probabilistic classifier: Bayes rule, Maximum Likelihood Estimation, case Study, Clustering :Unsupervised learning technique, Similarity and Distance Measures, k-means and k-medoids algorithm, optimization objective, random initialization, choosing value of k, EM algorithm. Framework for machine learning applications, human-computer interaction, Case studies in the domain of Measurement, Analysis and Control, etc.

Reference Books:

- Stuart J. Russell and Peter Norvig, —Artificial Intelligence A Modern Approach,‖ 3rd edition, Prentice Hall
- Tom Mitchell, —Machine Learning‖, McGraw-Hill, 1997
- EthemAlpaydin, —Introduction to Machine Learning‖, PHI, 2005
- Bishop, C., —Pattern Recognition and Machine Learning:,‖ Berlin: Springer-Verlag, 2006

Instrument Design Engineering

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes

1. Analyze and justify the requirement of Instrument and systems. [PEO1],[PO1]
2. Design various electronic circuits and measurement systems, noises identification and appropriate elimination methods related to instrument and system. [PEO1],[PO3]
3. Select, design appropriate enclosure, cables, PCB. [PEO1],[PO3]
4. Estimate, analyze, improve the reliability of instrument and system. [PEO1],[PO4]

Course Contents

Electromagnetic Compatibility: Noise, Interference, Noise Coupling, cabling, 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 radiations, Conducted emissions, RF and transient immunity, electrostatic discharge, PCB layout and design, EMC measurements. Standards, reliability, automated test equipment.

Reference Books:

- Henry W Ott, —Electromagnetic Compatibility Engineering||, John Wiley and Sons Inc. Publication, 2009 W. C. Bossshart , —PCB Design and Technology|| Tata McGraw Hill, 1987
- Clyde F. Coombs, —Electronic Instrument Handbook||, McGraw Hill, Third Edition, 2005

Advanced Control System

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

- **Formulate** and design the sliding mode controller for an application at hand
- **Understand** the need for special sliding mode controllers and its design
- **Design** the discrete time sliding mode controllers
- **Understand and synthesis** the stable higher order sliding mode controllers

Course Contents

Sliding mode control basics: Nonlinear control preliminaries, Types of Uncertainty-Matched and Unmatched uncertainties- Sliding modes in nature, Variable Structure Systems, Development of Sliding Mode Control (SMC), Concept of Sliding Surface, State feedback sliding surface design, Reachability Conditions, Switching Control Action, Chattering Phenomena, Fillipov Trajectories, Concept of Equivalent Control, Lyapunov stability theory. Special Sliding Mode Controllers: Integral Sliding mode control (ISMC)- Stability of ISMC- Terminal SMC- Stability of Terminal SMC- Composite nonlinear feedback (CNF) control- ISM with CNF control-Control law derivation- Stability of ISM-CNF control- Examples. Discrete Time SMC: Chattering in Continuous Time- Discrete time development-quasi-sliding mode-discrete reaching laws and sliding surface design- multirate output feedback- discrete time integral and terminal sliding modes- Design Examples. 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. J.J.E Slotine and W. Li, —Applied nonlinear control||, Prentice Hall, 1991.
3. Y. Shtessel, C. Edwards, L. Fridman, A. Levant, Sliding Mode Control and Observation, 1st Edition, Springer Birkhauser, 2014.
4. Bandyopadhyay B. and Janardhanan S., Discrete-time Sliding Mode Control: A Multirate Output Feedback Approach, 1st Ed., Springer. 2006.
5. Utkin V., Guldner J. and Shi J., Sliding Mode Control in Electromechanical Systems2nd Edition., Taylor and Francis, 2009.

6. B. Bandyopadhyay, Fulwani Deepak, Kyung-Soo Kim, Sliding mode control using novel sliding surfaces "1st Edition, Springer, 2009.
7. L. Fridman, J-P Barbot, Frank Plestan, Recent Trends in Sliding Mode Control, 1st Edition, IET Publisher, 2016.

Machine Vision and Image Processing

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes

1. Introduction of Acquisition of image and its processing.
2. Selection of sensor for the application
3. Application of various control techniques to Processes

Course Contents

Automation Overview and Image Acquisition: Introduction of Vision based automation, Types of Camera sensors (CMOS and CCD), camera types, types of Lenses, lens selection, illumination, camera selection, Image capture, Camera calibration, 3-D machine vision techniques. Image Processing: Types of images, Grey scale operation, image filtering, Edge detection and enhancement, Frequency filtering, Morphology functions, Geometric transformation, image compression, image restoration, modern 3D Methods for Automation Image Analysis: Pixel value analysis, Morphology Analysis, Quantitative analysis, Shape and pattern matching, Character recognition, Image focus quality Control and Estimation: Introduction and need of control, motors, drives, servo systems motion controller and types of motion control systems. Position and velocity measurement and feedback, Mechanical transformation, actuators used, planning and object tracking Tools and platforms used for Vision based automation: Image acquisition and processing, Video acquisition and processing using Lab VIEW (IMAQ Vision), PLC, Embedded system (various Vision interface software's) Case studies: Impact of vision-based system on industrial applications, Case study related to vision based solutions.

Reference Books:

- Milan Sanka, Vaclav Halavac, Roger Boyle "Image Processing, analysis and machine vision", Springer Publisher, 3rd ed., 2010.
- Thomas Klinger, "Image Processing with LabVIEW and IMAQ Vision", Prentice Hall; 2nd edition, 2003.
- Kenneth R. Castleman, Digital Image Processing, Prentice Hall, Englewood. Cliffs, 1 st edition, 1996.
- Pascal Bornet, Ian Barkin, Dr. Jochen Wirtz , "Intelligent Automation", Kindle Edition

Industrial Internet of Things

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes

- Understand, design and develop the real life IoT applications using off the shelf hardware and software. [PEO4],[PO4].
- Knowledge of Key components in the field of IIoT, Architectures and its pros and cons [PEO1],[PO1].
- Interpret the various IoT Layers and their relative importance in Business Models. [PEO3],[PO6].
- Use various IoT platforms and security for solving social and industrial problems.[PEO4],[PO4].

Course Contents

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:

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

Mechanics and Control of Robotic Manipulator

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

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

Course Contents:

Basics of Robotic Manipulator: Introduction robotic manipulator, Effector: locomotion, and manipulation. Serial and parallel manipulators. Descriptions, Transformations and homogeneous transformation matrix. Kinematics of Robotic Manipulator: Manipulator (serial manipulator) kinematics: Kinematic parameters, different notations, Denavit-Hartenberg (DH) representation, arm matrix. Forward and inverse kinematics. Analytical and numerical solutions. Examples, Differential kinematics: Differential (velocity) kinematics, velocity propagation, forward differential kinematics and inverse differential kinematics. Statics of Robotic Manipulator: 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. Examples.
Dynamics of Robotic Manipulator: Manipulator dynamics: Motion dynamics: Forward and inverse dynamics. Lagrangian (Lagrange-Euler) and Newton-Euler formulations. Examples, Dynamic simulation: Dynamic modeling of robotic manipulators and computer-based numerical simulations. Trajectory Tracking Control of Robotic Manipulator: 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

Process Modeling and Optimization

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes

1. Understanding of process model design using first principles, conversation principles and process data. [PEO1],[PO1]
2. Have an understanding of computational techniques to solve the process models. [PEO1],[PO4].
3. To solve and analyze optimization problem formulations. [PEO2],[PO4].
4. Get familiar with analytical techniques used to solve single objective, unconstrained and constrained optimization problems. [PEO1],[PO3]

Course Contents

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 of mathematical models, use of mathematical models, principles of formulation, fundamental laws, continuity equations, energy equations, transport equations, equations of state, equilibrium, kinetics. **Case study:** CSTR Model, boiler-heat exchanger model.

Model Solving: Solving non-linear simultaneous equations using Newton‘s Method. Ordinary differential equations and differential algebraic equations and solving ODE‘s and DAE‘s, partial differential equations, solution of PDE‘s by finite difference methods. 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. First derivative method, Newton‘s and quasi- Newton‘s method, conjugate gradient method of unconstrained optimization problems.

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:

- Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", 2nd Ed., McGraw Hill

- Edger, Himmelblau, Lasdon, Optimization of Chemical Processes,McGraw-Hill International, Edition
- S.S. Rao, "Engineering Optimization: Theory and Practice", New Age International P)Ltd., New Delhi.
- K. Deb, "Optimization for Engineering Design-Algorithms and Examples", Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.
- Denn M. M., "Process Modeling", Longman, 1986
- B Wayne Bequette, Process Dynamics: Modelling, Analysis and Simulation, Prentice Hall International Inc.

Digital Twin

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course outcomes

- Understand concept of digital twin
- Designing the architecture for Digital Twin
- Study various implantation techniques for various applications
- Analysis of digital twin for various applications

Course contents

Introduction to digital Twins, Types (Asset, Components, Systems and Process), characteristics, benefits, best practices in digital twin, Architecture, representation/modeling, sensing actuation system, connectivity protocols, Implementation techniques, Augmented reality, Virtual reality, Mixed reality, Extended reality, use of intelligence in designed twin for various analysis, Security measures, Simulation techniques for digital twins: agent-based modelling, systems dynamics, discrete event simulation, Case study of known applications, Applications of digital twins

Reference Books:

1. Zhihan Lv, Elena Fersman, "Digital Twins: Basics and Applications", Springer
2. Ali Kashif Bashir, Balamurugan Balusamy, Pooja Malik, Rajasekar Vani, Rajesh Kumar
3. Dhanaraj , "Digital Twin for Smart Manufacturing", Elsevier Science
4. Shyam Varan Nath, Pieter Van Schalkwyk, "Building Industrial Digital Twin", eBook
5. Bishop, C.M. Pattern recognition and Machine learning, Springer, 2007.
6. Abdulmotaleb El Saddik, "Digital Twin for Healthcare", Academic Press, Elsevier

Advanced Digital Signal Processing

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes

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

Course Contents

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.

Text Books

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.
2. Mitra, Sanjit Kumar, and Yonghong Kuo. Digital signal processing: a computer-based approach. Vol. 2 New York: McGraw-Hill Higher Education, 2006.

Semester-III

Dissertation Phase I

Teaching Scheme:
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Examination Scheme:
Marks: 100 each for phase I and II

Course Outcomes

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].

Course Contents

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

Semester-IV

Dissertation Phase II

Teaching Scheme:
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Examination Scheme:
Marks: 100 each for phase I and II

Course Outcomes

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].

Course Contents

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 topic
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