COEP Technological University, Pune

Formerly, College of Engineering, Pune
(A Unitary Public University of Govt. of Maharashtra, Wellesley Road, Shivajinagar, Pune- 411 005)

Department of Instrumentation and Control Engineering

Curriculum Structure & Detailed Syllabus (UG Program)

Third Year B. Tech. - T. Y. B. Tech.

(Revision: 2023-2027, Effective from 2025-26)

Program Education Objectives (PEOs):

PEO1: Core Competency: Graduate will solve real world problems appropriate to the field of Instrumentation & Control Engineering using foundation of mathematics and science.

PEO2: Breadth: Graduate will apply current industry accepted practices, new and emerging technologies to analyze, design, implement, and maintain the state-of-art solutions.

PEO3: Learning Environment: Exhibit self- learning capabilities to assimilate and practice emerging theories and technologies.

PEO4: Professionalism: Inculcate professional and ethical attitude and ability to relate automation issues to society at large as well as exhibit teamwork and effective communication skills.

PEO5: Preparation: Be successfully employed or accepted into a graduate program / higher studies, and demonstrate a pursuit of lifelong learning.

Program Specific Outcomes (PSOs)

PSO1. Design and deploy Instrumentation systems to enhance the performance of the industrial and real life applications.

PSO2. Devise innovative systems and control methodologies to cater the needs of the core industrial problems.

PSO3. Create knowledge base for ease in implementing advanced techniques for seamless integration of the technology for the real life applications.

Program Outcomes (POs):

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, to Instrumentation and Control discipline to the solution of complex engineering problems.

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

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7:Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8:Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9:Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

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

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

PO12:Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Correlation between the PEOs and the POs

PO→ PEO↓	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
PEO1	✓	✓	✓	✓		✓							✓		✓
PEO2	✓	✓	✓	✓	✓		✓							✓	
PEO3	✓	✓	✓	✓	✓				✓			✓			✓
PEO4								✓	✓	✓	✓		✓	✓	✓
PEO5									✓	✓	✓	✓	✓		✓

List of Abbreviations

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<tr><td>Basic Science Course</td><td rowspan="2">BSC/ESC</td></tr>
<tr><td>Engineering Science Course</td></tr>
<tr><td>Programme Core Course (PCC)</td><td rowspan="2">Programme Courses</td></tr>
<tr><td>Programme Elective Course (PEC)</td></tr>
<tr><td>Open/School Elective (OE/SE)</td><td rowspan="2">Multidisciplinary</td></tr>
<tr><td>Multidisciplinary Minor (MD M)</td></tr>
<tr><td>Vocational and Skill Enhancement Course (VSEC)</td><td>Skill Courses</td></tr>
<tr><td>Ability Enhancement Course (AEC-01)</td><td rowspan="5">Humanities Social Science and Management</td></tr>
<tr><td>Indian Language (AEC-02)</td></tr>
<tr><td>Entrepreneurship/Economics/ Management Courses</td></tr>
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<tr><td>Project</td></tr>
<tr><td>Community Engagement Activity (CEA)/Field Project</td></tr>
<tr><td>Co-curricular & Extracurricular Activities (CCA)</td><td>Liberal Learning Course</td></tr>
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Curriculum Structure of Third Year B. Tech (I & C)

(Effective from A. Y. 2025-2026)

Semester-V

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	PCC-08	Digital Signal Processing	2	1	2	1	4	PCC
02	PCC-09	Control System Design	3	0	2	1	4	PCC
03	PCC-10	Process Loop Components	2	0	2	1	3	PCC
04	PEC-01	Program Elective Course-I	3	0	0	1	3	PEC
05	OE-03	Sensors and Actuators	2	0	0	1	2	OE
06	OJT-1	Internship	--	--	--	--	1	OJT
07	VSEC- 02	Project Stage I	--	--	4	--	2	VSEC
08	MD M- 02	Multidisciplinary Minor-II	3	0	2	1	4	MDM
Total Academic Engagement and Credits			**15**	**01**	**12**	**06**	**23**	

Program Elective Course-I

1. Process Plant Operations
2. IoT and Multi Sensor data Fusion
3. Data Structures and Algorithms
4. Anatomy and Physiology
5. Computer Architecture and Programming

Multidisciplinary Minor-II

Semester - VI

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	PCC-11	Power Electronics and Drives	2	0	2	1	3	PCC
02	PCC-12	Analytical Instrumentation	2	0	2	1	3	PCC
03	PCC-13	Industrial Automation	3	0	2	1	4	PCC
04	PCC-14	Instrument System Design	2	0	2	1	3	PCC
05	PEC-02	Program Elective Course-2	3	0	0	1	3	PEC
06	VSEC- 02	Project Stage II	0	0	4	--	2	VSEC
07	MDM- 03	Multidisciplinary Minor-IIT	3	0	2	1	4	MDM
Total Academic Engagement and Credits			**15**	**00**	**14**	**06**	**22**	

Department Electives-III

1. Robotics and Automation
2. Industrial Communication and Programming
3. Fundamental of Machine Learning
4. Medical Devices
5. Industrial Internet of Things
6. Embedded Programming

Multidisciplinary Minor-III

***Exit option to qualify for B. Voc.: Internship of 8 Weeks**

Digital Signal Processing

Teaching Scheme
Lectures: 3hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- **Apply** DFT and FFT methods for various signals and determine their frequency response
- **Design and analysis** of FIR filters using different techniques.
- **Design and analysis** of IIR filters using different techniques.
- **Design and analyze** multi-rate system.

Course Contents

Unit I **(07hrs)**
Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT): Introduction, Discrete Fourier transform of discrete time signal, properties of DFT, relation between DFT & Z transform, analysis of LTI discrete time systems using DFT, Fast Fourier transform, decimation in time algorithm, decimation in frequency algorithm, computation of inverse DFT using FFT.

Unit II **(06hrs)**
FIR Filters: Finite Impulse Response Filters - Introduction to finite impulse response filters, linear phase filters, symmetric & anti –symmetric filters, Design of FIR filter: windowing method, analysis of different types of windows, frequency sampling method, optimal equiripple, FIR differentiators.

Unit III **(07hrs)**
IIR Filters: Infinite Impulse Response - Filter Introduction to Infinite Impulse Response filter, Butterworth, Chebyshev approximation. Design of IIR filters: Impulse invariant method, bilinear transformation, approximation derivative method, IIR filters design using least square method, Frequency transformations - low pass to high pass, band pass, band reject.

Unit IV **(08hrs)**
Multi-Rate Filters and Sampling: Changing the sampling rate, Down sampling, Up sampling, Fractional rate changes, Poly phase Decomposition, Narrowband filter banks, Delay Systems, Integer sampling rate converters, Rational sampling rate converters, Multi rate filter realization structures

Self Study: Realization of FIR Systems, Realization of IIR Systems

Text Books

- A. Nagoor Kani, "Digital Signal processing", Tata McGraw Hill 2nd edition 2012.
- P. Ramesh Babu, Digital Signal Processing", Scitech, 7th edition, 2011.
- Proakis, Manolakis, "DSP Principles, algorithms and applications-, Pearson, Fourth edition, 2009.

Reference Books

- A Antoniou, "DSP filter analysis and Design", McGraw Hill, 1979
- Oppenheim and Schafer, "Discrete time signal processing", Pearson Publication, 2nd edition, 2007

Digital Signal Processing Laboratory

Teaching Scheme
Lectures: 2 hrs./week

Examination Scheme
Continuous Assessment: 50 Marks
Practical Exam- 50 Marks

Course Outcomes:

- Understand the basic operations of signal processing & plot basic discrete/digital signals using MATLAB.
- Analyze and examine the sampling theorem
- Demonstrate interpolation and decimation operations.
- Evaluate magnitude and phase spectrum of a discrete time signal using DFT to determine the spectral components of the signal.
- Develop and design IIR and FIR band pass, band stop, low pass and high pass filters.

[Perform any 10 experiments using any simulation software]

1. Computation of impulse response of LTI system for given transfer function find the impulse response and print the output sequence using DSP LCDK6748 kit
2. Determine the DFT and IDFT of a given input signal.
3. Implementation of FFT algorithm.
4. Design a FIR filter with windowing technique
5. Design the IIR Butterworth filter
6. Design the IIR Chebyshev filter
7. Program for illustration of upsampling
8. Program for illustration of effect of upsampling in frequency domain
9. Program for illustration the effect of anti-imaging filter
10. Program for illustration of downsampling
11. Program for illustration of effect of downsampling in frequency domain
12. Program for illustration the effect of anti-aliasing filter

Control System Design

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- An ability to design controller in time domain and frequency domain
- An ability to design controller in state space
- Ability to design observer
- Ability to design compensators in time and frequency domain

Course Contents:

Unit I **(07 hrs)**

Compensator design with root locus: transient response via gain adjustment, improving time domain specifications (steady state error, transient response) by cascade compensation, feedback compensation

Unit II **(07 hrs)**

Controller design: Design of Proportional (P), Integral (I), Derivative (D), PI, PD, PID controllers, lead, lag, lead-lag controller by root locus method.

Unit III **(08 hrs)**

Design of controller in frequency domain: Design of controller with bode plot, improvement of steady state and transient response with lead, lag, lead lag compensator design

Unit IV **(09 hrs)**

State Space: General state space representation, converting state space to transfer function and vice versa controller design introduction, design with state feedback controller and Ackerman's formula, Observer Design: Pole placement, solving pole placement with MATLAB, Controllability, different approaches for controller design, Introduction to observer, full order and reduced order observer, observability, different approaches for observability design, Output feedback.

Unit V **(09 hrs)**

Optimal control of mechanical systems: Quadratic optimal regulator systems, Continuous time linear quadratic regulator (LQR), Steady state and sub optimal control, minimum time and constrained input design, LQR with output feed back, tracking problems, Kalman filter, Linear quadratic Gaussian (LQG) design, LQG/LTR design

Reference Books

- Franklin G.F., Powell J.D., Emami-Naeini A., Feedback Control of Dynamic Systems, Pearson, Upper Saddle River, New Jersey, 5th edition, 2006.
- Ogata K., Modern Control Engineering, Prentice-Hall of India Pvt Ltd., New Delhi, 3rd edition, 2000.
- Kuo B.C., Automatic Control Systems, Prentice-Hall of India Pvt Ltd., New Delhi, 6th edition, 1991.
- Brogan W. L., Modern Control theory, Prentice Hall International, New Jersey.

Control System Design Laboratory

Teaching Scheme
Practical: 2 hrs./week

Examination Scheme
Continuous Assessment: 50 Marks
Practical Exam- 50 Marks

Course Outcomes:

- Able to design controllers and observer for general systems to validate performance on real time system
- Able to design and PI, PD, PID controllers and evaluate the performance

- Able to design and validate the effect of uncertainty and disturbances on controller and observer design

[Perform any 10 experiments using any simulation software]

1. Simulation of a lag, lead and lead-lag compensator for a given linear system and comparison of compensated and uncompensated systems responses.
2. Design of PI, PD and PID controller using time and frequency domain Specifications
3. Software program for determining a state-space model for a given transfer function and vice versa.
4. Software program for determining the state transition matrix.
5. Software program for checking the observability and controllability of a given system.
6. Simulation of state feedback control design using software.
7. Simulation of a full-order observer-based state feedback control system.
8. Design of a linear quadratic regulator for a given system using simulation
9. Study effect of uncertainty and disturbance on system performance
10. Validation of PID controller design on DC Motor set up (position and speed control).
11. Validation of lag-lead compensator design on second order electric network.

Process Loop Components

Teaching Scheme
Lectures:2hrs./week
Self study: 1hr/week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Examine the operation of the transmitter, final control elements, pneumatic and hydraulic components generally used in plants
- Design the required features of transmitter, final control elements, pneumatic and hydraulic components for specific application
- Review the performance of the transmitter, final control elements, pneumatic and hydraulic components
- Simulate and solve the problems associated with the functioning of transmitter, pneumatic system, and hydraulic system in instrumentation and control engineering.

Unit I (08 hrs)

Auxiliary Components: Manual switches, Mechanical switches, Relays: Electromechanical, Relay Logic, Solid state relays, relay packages Contactors: Comparison between relay & contactor, contactor size and ratings

Unit II (08 hrs)

Final Control Elements: Operation of control valve, Classification of control valves based on: Valve body. Construction, Advantages, Disadvantages & applications, Types of actuators: Spring Diaphragm, Piston cylinder(power cylinder), Pneumatic, Hydraulic, Electro-hydraulic, Electric, and smart actuators, fail-safe operation. Control valve terminology: Range ability, valve capacity, Flashing, Cavitations, dead band, response time, Control valve characteristics:

Inherent & installed, Valve sizing. Positioners: Application/Need, Types, Effect on performance of control valves, Volume boosters, Pressure Boosters etc.

Unit III **(08 hrs)**

Introduction to Transmitters: Function of a transmitter, types, signal conditioning, characterization and calibration, Installation, Commissioning and trouble shooting of a transmitter, auxiliary components like manifolds etc. SMART transmitter: Comparison with conventional transmitter, Block schematic. Function of a converter, types (I/P and P/I), signal conditioning, characterization and calibration, Installation, commissioning, and trouble shooting of a converter, auxiliary components like lock down relay etc.

Unit IV **(08 hrs)**

Pneumatic Supply and its components: Filter Regulator Lubricator (FRL), Single acting & Double acting cylinder, Special cylinders, Operation of Direction Control valves, Types of pilot signal, operation of speed regulators, pressure control valve, Special valves like quick exhaust, pressure, time delay valve, Standard Symbols for pneumatic components Pneumatic Circuits: Sequence diagram (step-displacement) for implementing pneumatic circuits, Different Pneumatic Circuits using standard symbols for components: direct acting control, indirect acting control, pressure sequencing, block transfer etc.

Hydraulic supply: reservoir, Types of filters, Function of accumulators, Hydraulic Actuators, Operation of Direction Control Valve, Standard symbols for hydraulic components, Hydraulic Circuits: Meter in, Meter out, Reciprocating, speed control, Sequencing of cylinders, Direction control, applications

Text Books

- Norman A. Anderson , "Instrumentation for Process Measurement and Control", CRC Press, Third Edition, 1980
- Industrial Electronics ,Petruzella (Manual),Tata McGraw Hill.
- Pneumatic Instrumentation by Majumdhar, TMH

Reference Books

- William Andrews, "Applied Instrumentation in Process Industries", Gulf, Second Edition, 1979
- B. G. Liptak, "Process Control, Instrument Engineering Hand book", Chilton Book Company, Third Edition, 1995
- Control Valve Handbook, Fisher Controls International, Inc. third Edition, 2001

Process Loop Components Laboratory

Teaching Scheme

Practical: 2 hrs./week

Examination Scheme

Continuous Assessment: 50 Marks

Practical Exam- 50 Marks

Course Outcomes:

- Design signal conditioning circuit for given transmitter design.
- Understand and operate final control element
- Understand standard symbols used for components in industry
- Select and use pneumatic components to build pneumatic circuit for given application.
- Formulate and solve a problem based on learned components.

List of Experiments:

1. Design of signal conditioning for a K-type thermocouple/ RTD
2. Configuration of D.P Transmitter and its application for flow measurement
3. Development of mathematical model of control valve
4. Calibration and fault finding of I/P converter
5. Size a control valve for given applications
6. Study of control valve & plot the characteristics of control valve
7. Design High/Low selector for given application
8. Design alarm Annunciator for given application
9. Learn operation of pneumatic components like DCVs, time delay valve, pressure sequence valve, etc
10. Design and develop pneumatic circuit to operate single acting and double acting cylinder
11. Design and Develop pneumatic circuit to press glued components
12. Design and Develop pneumatic circuit for plastic components embossing
13. Design and Develop pneumatic circuit to transfer block from a magazine.
14. Design and develop pneumatic circuit for sequencing of cylinders
15. Design and develop electro-pneumatic circuit
16. Designing intrinsic safety circuits (Zener barrier)
17. Field Visit

Process Plant Operations

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Knowledge of unit operations and effect of different parameters on these operations.
- Acquaintance with different equipment used for unit operations.
- Apply basic measures to control and monitor unit operations.
- Propose/Design the unit operation sequence and equipment required in different industries.

Course Contents

Unit I **(04 hrs)**

Introduction: Unit operations and unit processes. Basic concepts of corrosion and protection from corrosion. Selection materials, metals & alloys used in construction of field instruments for different applications.

Unit II **(08 hrs)**

Transportation of Fluid & Equipment: Definition and classification, Rheological behavior of fluids & Newton's Law of viscosity. Fluid statics-Pascal's law, Basic equations of fluid flow – Continuity equation, and Bernoulli equation; Types of flow – laminar and turbulent; Reynolds experiment. Basic understanding about piping, valves. Specifications and working of pumps, compressors, fans, blowers. Selection of equipment and its material for different applications.

Unit III **(08 hrs)**

Heat transfer and Equipment: Modes of heat transfer; Conduction–steady state heat conduction, Convection- Forced and Natural convection, principles of heat transfer co-efficient, log mean temperature difference, individual and overall heat transfer co-efficient, fouling factor. Basic principles, working and selection criteria and control for double pipe, shell & tube heat exchangers, boilers, condensers, evaporators, cooling towers.

Unit IV **(08 hrs)**

Mass transfer and Equipment: Mass, heat, and momentum transfer analogies Material balance with or without chemical reactions mass transfer coefficients. Principles, working design considerations and control for equipment used for unit operations like distillation, extraction, drying, humidification, dehumidification.

Unit V **(08 hrs)**

Mechanical particulates and Screening and Equipment: Introduction of Particulate Sizes and Shapes, Principle, working design considerations and control for equipment used for unit operations like Screening, Size Reduction, Filtration Cross Flow Filtration and Membrane Separations, Gravity Sedimentation Processes, Centrifugal Separations, Floatation

Unit V **(04 hrs)**

Unit operations in different industries: Identification and justification of unit operations used in different industries like food, pharma, paper, sugar, cement, fertilizer, Petrochemical industry with help of process flow diagram.

Text Books:

- Unit operations in Chemical Engineering by Warren L. McCabe, Julian C. Smith & Peter Harriot, McGraw-Hill Education (India) Edition 2014.
- Transport Process Principles and Unit Operations by Christie Geankoplis, Prentice Hall of India.

Reference Books:

- Instrument Engineers Handbook: Process Control by Bela G Liptak, Pearson Education, Third ed., 1985.

IoT and Multi Sensor Data Fusion

Teaching Scheme

Lectures: 3 hrs./week

Examination Scheme

Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Understand communication protocol and components of IOT
- Solving issues related to networking and routing
- Understand communication platform for data fusion
- Simulate and solve the problems associated with the data fusion

Unit I **(08 hrs)**

Basics of IoT: Sensors- Sensor Basics, Role of sensors in IoT, Applicability of Sensors in different Industries. Design of sensors, Special requirements for IoT sensors, Sensor architecture. Actuators basics- Types of Actuators, Field Networks, Overview of wired and wireless, Topologies of Networks. Protocols- Overview of Protocols like ZIGBEE, ZWAVE, MBUS, 6LoWPAN, OPC-UA

Unit II **(08 hrs)**

Components of IoT: Different IoT networks & connectivity, Modes of communications. Overview of various IoT protocols like - COAP, 6LoWPAN, LWM2M, MQTT, AMPQ etc. Understanding of Edge and FOG Device Architectures. Influence of non-functional requirements on Edge and FOG devices. Edge/FOG Hardware selection criteria. Software Architecture of Edge/FOG devices

Unit III **(08 hrs)**

Introduction to Wireless Sensor Network: Coverage, Topology management), Mobile Sensor Networks, Classification of MAC protocols, MAC related properties, MAC performance issues, MAC protocols for sensor networks, Issues with the adoption of ad hoc routing protocols, Data-centric routing, Position-based routing, Data aggregation, Clustering-based routing algorithm, Case studies

Unit IV **(04 hrs)**

Introduction to Data Fusion: Role of sensors, Characteristics, Framework, Architecture, Fusion Node properties

Unit V **(08 hrs)**

Data Fusion: Simple Fusion Networks, Network Topology, Spatial-temporal Transformation, Geographical Information System, Subspace Methods, Multiple Training Sets. Node Management Hierarchical Classification, Sensor Management Techniques, Real life applications

Text Books

- Introduction to IOT, Sudip Mishra Anandarup Mukharjee, Cambridge University Press
- Principles of Wireless Sensor Networks, Mohammad S Obaidat, Sudip Mishra, Cambridge University Press
- Data Fusion: Concept and Idea, H B Mitchell, Springer

Anatomy and Physiology

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Describe human body structure.
- Understand working of different physiological systems of human body.
- Explain the functioning of the human body system.
- Understand biological control and feedback mechanism.
- Apply knowledge of human anatomy and physiology to solve different biomedical research problems.

Course Contents

Unit I **(03 hrs)**

Introduction to cell, Blood: Characteristics of blood, physiology of blood clotting, biochemical cycle

Unit II **(08 hrs)**

Heart (Circulatory System)-Anatomy of heart and blood vessels, origin and conduction of heartbeat, cardiac cycle, electrocardiogram, blood pressure, control of cardiac cycle. Respiratory System- Anatomy of respiratory system, physiology of respiration in the alveolar and tissue capillaries, control of respiration.

Unit III **(04 hrs)**

Digestive system: Anatomy of digestive system, nerve and blood supply, physiology of digestion. Kidney and Urinary system - Anatomy of urinary system and kidney, physiology of water and electrolyte balance, acid-base regulation.

Unit IV **(08 hrs)**

Muscle Tissues - Anatomy, types of muscles, physiology of muscle contraction, generation of action potential, rhythmicity of cardiac muscle contraction, properties of skeletal and Cardiac muscles.

Unit V **(09 hrs)**

Nervous system - Neuron, anatomy and function of different parts of brain, spinal cord, autonomic nervous system, Sensory system - Visual, auditory, Vestibular Endocrine system-pituitary, thyroid, parathyroid, adrenal, pancreas, biological control and feed-back mechanism, clinical and technological implications

Reference Books:

- "Ross & Wilson Anatomy and Physiology in Health and Illness", by Allison Grant, Anne Waugh, and Kathleen J. W. Wilson
- Anatomy and Physiology for Engineers- A handbook for biomedical engineers- by P. Manimegalal

Computer Architecture and Programming

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- **Explore** tools and techniques of writing efficient and optimized codes.
- **Understand** computer organization and architecture.
- **Describe** the principles of computer architecture.
- **Understand** the fundamentals of system software and role of operating system in achieving parallel processing.
- **Understand** the ways of Power and Performance Optimization in a computer system.

Course Contents

Unit I **(06 hrs)**

Programming Fundamentals and Tools: Introduction to GNU Toolchain (GCC, GDB, Makefiles), Concepts of C and C++ programming, coding standards and code analysis, writing efficient and optimized codes, use of GenAI tools for writing, debugging and testing codes.

Unit II **(06 hrs)**

Software Engineering: Introduction, Software Development Life Cycle, Requirement gathering and analysis, Use Case Modeling. Software Testing and Quality Assurance – levels of testing, testing techniques.

Unit III **(08 hrs)**

Introduction to Computer Organization: Overview of computer organization, Brief history of computer development; Hardware Components - CPU: structure, function, and types, Memory main memory, virtual memory, caching, I/O devices -peripherals, interfaces; Memory Management-memory organization, Virtual memory-concept, advantages, and disadvantages, Caching-concept, types, and cache hierarchies; Input/ Output Systems-peripherals and Interfaces.

Unit IV **(06 hrs)**

Introduction to Computer Architecture: Overview and history of computer architecture, CISC, RISC, and ARM Architectures, Bus Architecture - Bus types: system bus, I/O bus, Bus protocols - synchronous and asynchronous buses; Parallel Processing and Multi-Core Architecture.

Unit V **(06 hrs)**

System Software: Introduction to Operating System - Operating System Concept, Roles, and Operations, process, thread, and memory management, process scheduling, memory allocation, and I/O management, booting, login, and system calls, types of operating system.

Reference and Text Books

- Kernighan, B. W., & Ritchie, D. M. (1988). The C programming language. prentice-Hall.
- Deitel, P., & Deitel, H. (2016). C++ how to Program. Pearson.
- Stallman, R., Pesch, R., & Shebs, S. (1988). Debugging with GDB. Free Software Foundation.
- Bast, R., & Di Remigio, R. (2018). CMake Cookbook: Building, testing, and packaging modular software with modern CMake. Packt Publishing Ltd.
- Hayes, J. P. (2022). Computer architecture and organisation. Tata McGraw Hill.
- Harris, S., & Harris, D. (2021). Digital Design and Computer Architecture, RISC-V Edition. Morgan Kaufmann.
- Deitel, H. M., Deitel, P., & Choffnes, D. R. (2003). Operating systems. Prentice Hall.

Sensors and Actuators

Teaching Scheme	**Examination Scheme**
Lectures:2hrs./week	Teachers Assessment (TA): 20 Marks

Self study: 1hr/week

Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- **Select and specify** a sensor actuator system for an application.
- **Implement** a sensor and actuator system for discrete and continuous processes.
- **Identify** the lacunas in the existing sensors selection and suggest improvements.
- **Troubleshoot** the given sensors and actuators systems and commission it in a stipulated time.
- **Develop** a prototype for effective implementation of automation at level zero.

Course Contents

Unit I **(06 hrs)**

Overview of sensors and Transducers: Case studies based on selection, specifications, installation, commissioning, and troubleshooting of various sensors used for measurement of temperature, pressure, level, and flow

Unit II **(06 hrs)**

Implementation case studies: Case studies based on various applications in the area of construction, refrigeration, automotive, and traffic control system

Unit III **(08 hrs)**

Actuators: Working, designing, selecting, and troubleshooting of pneumatic, hydraulic, and electrical actuators. Case studies comprising of application of actuator knowledge in real life situations and in chosen plants.

Unit IV **(08 hrs)**

Based on various applications and interfacing of sensors in chosen fields, actuators, safety aspects, maintenance and trouble shooting of sensor actuator systems

Self-study

Overview of discrete and continuous processes characteristics, requirements, specifications, used cases, and cost considerations, block schematic of control loop, various parameters to assess performance, Case studies based on selection, specifications, installation, commissioning, and troubleshooting of various sensors used for measurement of displacement, velocity, and acceleration

Text Books

- Norman A. Anderson , "Instrumentation for Process Measurement and Control", CRC Press, Third Edition, 1980
- D.V.S. Murthi, "Instrumentation and Measurement Principles", PHI, New Delhi, Second ed. 2003.
- D. Patranabis, "Principle of Industrial Instrumentation", Tata McGraw Hill, Second ed., 1999.
- B. C. Nakra and K. K. Choudhari, "Instrumentation Measurements and Analysis" by, Tata McGraw Hill Education, Second ed., 2004.
- S. R. Majumdar, "Pneumatic systems", McGraw Hill Education Pvt Ltd, 2016
- Fisher Controls International, "Control Valve Handbook", Third Edition, 2001

Project Stage-I

Teaching Scheme
Practical: 4 hrs./week

Examination Scheme
Continuous Assessment: 50 Marks
Practical/ Oral Exam- 50 Marks

Course Outcomes:

- Able to apply the knowledge and skills previously gained into practice.
- Take appropriate decision with respect to various parameters related to production of a system or sub-system.
- Demonstrate the leadership quality along with ability to work in a group.
- Prove the ability to present the findings in a written report or oral presentation.

Course Contents

- Students are required to develop various modules required for their final year project, or a minim project e.g. power supply, processor module, interfacing module, display and signal conditioning module. The PCB and enclosure design is part of the activity of this subject. Testing of various modules as per industrial standards and practices is part of the experimental work. System Design Selection of sensors, signal conditioning, standard signals and noise considerations of typical systems. Student has to develop a mini project which will handle and measure a physical parameter such as temperature, pressure, vibration.
- The project Stage-I shall be carried out in-house i.e. in the department's laboratories/centres by a group 2 – 3 students. In any case the group shall not consist of more than three students.
- The project Stage-I shall consist of design and implementation of any suitable electronic system, sub system or circuit based on knowledge and skills previously gained.
- The project Stage-I outline (a brief or condensed information giving a general view of project topic) on the selected topic should be submitted to the course coordinator for approval within one weeks from the commencement of the term.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation.
- Deliverables: A project stage-I report as per the specified format (available on in the department and institutes website), developed system in the form of hardware and/or software. In addition, student shall maintain a record of attendance and continuous progress (log book in appropriate format available on institute/department's web site) duly signed by course coordinator and present as project stage-I deliverable along with report.

Evaluation System:
It includes Internal Continuous Assessment (ICA) and End Semester Examination (ESE). Guidelines for ICA and ESE are given below.

Internal Continuous Assessment (ICA)

- The ICA shall be evaluated by course coordinator.
- Course coordinator shall judge the students on the principle of continuous evaluation and contribution of individual student in the group.

- It shall be evaluated on the basis of deliverables of project stage-I and depth of understanding.
- Course coordinator shall maintain the record of continuous evaluation in appropriate format available on institute/department's web site.

End Semester Examination (ESE)

- The End Semester Examination for this course shall be based on demonstration of the system or sub system developed by the group of students, deliverables of project stage-I and depth of understanding (oral examination). It shall be evaluated by two examiners out of which one examiner shall be out of institute.

Internship

Teaching Scheme
Practical: 6 hrs./week

Examination Scheme
Continuous Assessment: 50 Marks
Final Oral Exam- 50 Marks

Course Outcomes:

- Demonstrate an understanding of industrial practices, challenges, and work ethics.
- Apply theoretical and technical knowledge to practical, real-world industry problems.
- Work collaboratively in professional environments and communicate effectively.
- Identify gaps in their knowledge and acquire new skills relevant to industry requirements.
- Prepare detailed documentation and deliver technical presentations based on internship work

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

Power Electronics and Drives

Teaching Scheme
Lectures: 2 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Understand, select and analyze operations of different power devices for different power electronics applications [PO1]
- Classify, select and design different converters for various practical applications [PO3]
- Understand the importance of power quality aspect [PO2]
- Analyze different machine drives [PO3]
- Understand and apply different control strategies for power converters [PO1]

Course Contents

Unit I **(08 hrs)**

Rectifiers and Converters: Diode rectifiers - Single Phase, three phase and polyphase; Controlled rectifiers – Single phase, three phase, PWM rectifiers and power factor improvement techniques; DC-DC Converters – Choppers, Buck converter, Boost converter, Buck-Boost converter, Cuk converter, Bidirectional converters, Applications of DC-DC Converters

Unit II **(08 hrs)**

Inverter and Cycloconverter: Inverters – Introduction, Single phase & Three phase Voltage Source Inverters, Current source inverters, Close loop operation of inverters, multi-stage inverters; AC-AC converters – Single phase AC-AC voltage converter, three phase AC-AC converter, Cycloconverter, Matrix converter

Unit III **(08 hrs)**

Machine Drives: DC motor drives, Induction motor drives, synchronous motor drives, Permanent magnet synchronous motor drives, Permanent magnet brushless DC motor drives, Servo drives, stepper motor drives, switched reluctance motor drives, synchronous reluctance motor drives, Sensorless vector and Direct torque-controlled drives

Unit IV **(08 hrs)**

Control Methods for Power converters: Introduction – Linear & non-linear control in power electronics, Power converter control using state space averaged models, sliding mode control of power converters, introduction to Fuzzy logic and AI based control of power converters.

Text Books

- Power Electronics – Converters, Applications and Design, Ned Mohan, Undeland, Riobbins, Wiley Student 3rd Edition2003 Edition, 2015
- Electric Motors and Drives – Fundamentals, types and Applications, Austin Huges& Bill Drury, Newnes Publication 4th Edition, 2013

Reference Books

- Power Electronics – Drives, Circuits and Applications, Muhammad H. Rashid, Pearson Publication 4th Edition, 2014
- Fundamentals of Power Electronics, Robert W. Erickson & Dragan Maksimovie, Springer, 2nd Edition, 2001

Power Electronics and Drives Laboratory

Teaching Scheme
Practical: 2 hrs./week

Examination Scheme
Continuous Assessment: 50 Marks
Practical Exam- 50 Marks

List of Experiments:

1. To study and analyse the operation, characteristics, and output waveforms of:a Single-Phase Half-Wave Controlled Rectifier, and a Single Phase Full-Wave Controlled Rectifier
2. To study and analyse the operation, characteristics, and output waveforms of: a Three-Phase Half-Wave Controlled Rectifier, and a Single Phase Full-Wave Controlled Rectifier
3. Study and Performance Analysis of DC-DC Boost Converter
4. Study and Performance Analysis of DC-DC Buck Converter
5. Study and Performance Analysis of DC-DC Boost-Buck Converter
6. Study and Performance Analysis of Bidirectional converter
7. Study and Analysis of DC Motor Drives
8. Study and Analysis of Permanent Magnet Brushless DC (PMBLDC) Motor Drives
9. Study of Power Converter Control Using State-Space Averaged Method
10. Study of Speed Control of DC Motor Using Voltage Controlled Method

Analytical Instrumentation

Teaching Scheme
Lectures: 2 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:
At the end of the course, a student will be able to:

- Select the required instruments for spectroscopic analysis. [PEO1][PO-3]
- Understand the effects of different constituent in a process outcome and analysis the performance of various on-line or off-line instruments. [PEO3][PO-10]
- Apply the knowledge of chromatography to separate the constituents from a complex mixture. [PEO1][PO-11]
- Distinguish gas analyzer based on different principles [PEO2][PO-5]
- Interpret/ summarize chemical sensors and associated research in analytical instrumentation [PEO3][PO-12].

Course Contents

Unit I **(07 hrs)**
Introduction to Chemical instrumental analysis, advantages over classical methods, classification: Spectral, electro analytical and separative methods, Interaction of radiation with matter, Source (continuous and LASER), detector and optics design, Benchtop type colorimeter,online colorimeter for process applications, turbidity meter, turbidity analyzers and its applications

Unit II **(07 hrs)**

UV-Visible spectrophotometers and its types with its optical system design and its applications, UV and Visible analyzers with its applications in process industries, FTIR spectrophotometers and its applications

Unit III **(07 hrs)**

Classification of Chromatographic methods, Gas chromatography, Process Gas Chromatograph, High Performance Liquid Chromatography (HPLC), applications in industries such as process, food and pharmaceuticals, ICP- mass spectrometer

Unit IV **(07 hrs)**

Types of gas analyzers based on measurement of quantities such as infrared absorption, chemiluminescence, Introduction to chemical sensors based system design , semiconductor gas sensors for trace gas analysis and monitoring

Self Study :

Emission spectroscopy: Flame Photometry: Principle, constructional details, flue gases, atomizer, burner, optical system, recording system.

Atomic absorption spectrophotometers: Theoretical concepts, instrumentation: hollow cathode lamps, burners and flames, plasma excitation sources, optical and electronic system

Gas analyzers based on parmagnetic, zirconia, and thermal conductivity, Voltametry and conductometry based liquid analyzers.

Text Books:

- Instrumental Methods of Analysis, Willard, Merritt, Dean, Settle, CBS Publishers & Distributors, New Delhi, Seventh edition.
- Handbook of Analytical Instruments, R. S. Khandpur, Tata McGraw–Hill Publications, 3rd edition
- Principles of Instrumental Analysis, Skoog, Holler, Nieman, Thomson books-cole publications, 5th edition.

Reference Books:

- Instrumental Methods of Chemical Analysis, Galen W. Ewing, McGraw-Hill Book Company, Fifth edition.
- Introduction to Instrumental Analysis, Robert D. Braun, McGraw-Hill Book Company.

Analytical Instrumentation Laboratory

Teaching Scheme

Practical: 2 hrs./week

Examination Scheme

Continuous Assessment: 50 Marks

Practical Exam- 50 Marks

List of Experiments:

1. Design a handheld visible spectrophotometer for qualitative analysis of sample
2. Visible spectrophotometer for qualitative and qualitative measurement of sample
3. UV-Visible spectrophotometer for qualitative and qualitative measurement of sample and compare the results with Visible spectrophotometer.
4. To analyze a given liquid sample using combinations of light source and detectors and evaluate its performance
5. Turbidity sensor system for liquid sample analysis
6. Design a gas sensor system and evaluate its performance.
7. Design Thermal conductivity detector using open-source software
8. Analyze GC data and comment on its performance parameters
9. Analyze HPLC data and comment on its performance parameters
10. Design chemical sensor system

Industrial Automation

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Examine hierarchy of Industrial Automation
- Solve the problem in control network
- Demonstrate functions of Programmable Logic Controller
- Develop control logic for engineering system

Course Contents

Unit I (08 hrs)
Introduction to Automation: Evolution of instrumentation and Control, types of industries, Benefits of automation, Computer based- Plant Automation, Evolution of Hierarchical system structure, Continuous versus Discrete Process Control

Unit II (08 hrs)
Instrumentation Standard Protocols An introduction to network, Introduction to open system interconnection (OSI)model, overall fieldbus trends, Instrumentation Network Design, Fieldbus advantages and disadvantages, HART Network, Foundation Fieldbus Network, Modbus TCP/IP , Ethernet and TCP/IP based system

Unit III (08 hrs)
Introduction to Programmable Logic Controller, Architecture of PLC, Types of Input & Output modules (AI, DI, AO, DO), wiring diagram, ladder diagram using standard symbols, PLC specifications, PLC manufacturers, PLC ladder diagram, basic instructions, Times, counters instruction with timing diagram, advanced instructions,

Unit IV (08 hrs)
Introduction to SCADA and Its Applications, Automation of pump house, Motor Control Centre (MCC), elevator, drilling station, bottle filling station

Unit V (08 hrs)

Distributed Control System: Introduction to Distributed Control System, Functional level, data base organization, Operator interface, Introduction to Object Linking and Embedding (OLE) for Process Control, application software, and Knowledge-based software

Unit VI **(08 hrs)**

Hazardous Area Classification and Safety: Hazardous area classification as per IEC standard, Protection Methods, Explosion Proof Housing, Encapsulation, Sealing, & Immersion, Purging systems, intrinsic safety, Concept of safety cycle

Text Books

- Gary Dunning , "Introduction to Programmable Logic Controller", Cengage Learning India Pvt. Ltd., Third Edition, 2006
- John W. Webb, "Programmable Logic Controllers", Prentice Hall, Fourth Edition, 1999

Reference Books

- B. G. Liptak , "Process Control, Instrument Engineering Hand book", Chilton Book Company, Third Edition, 1995
- B. G. Liptak, "Process Software and Digital Networks", CRC Press. Third Edition 2000

Industrial Automation Laboratory

Teaching Scheme
Practical: 2 hrs./week

Examination Scheme
Continuous Assessment: 50 Marks
Practical Exam- 50 Marks

Course Outcomes:

- Understanding of architectures of Programmable Logic Controller
- Understanding communication protocol and networking with controller
- Develop programming skills for Programmable Logic Controller
- Solve engineering problem using programming language

List of Experiments:

1. Implementation of logical function using PLC programming
2. Implementation of Timer and counter for a given applications using PLC programming
3. Implementation of PLC programming for applications like elevator, bottle filling, motor control center
4. Interfacing PLC to Pneumatic circuits
5. Interfacing PLC to Variable Frequency Drive
6. Study of HART protocol
7. Communicate field devices using fieldbus protocol to delta V controller
8. Study of Delta-V distributed control System architecture
9. Configuration and commissioning of Digital I/O's
10. Configuration and commissioning of Analog I/O's for a typical system.
11. Configuration and commissioning of control block for a typical system.
12. Configure PID block for given control loop
13. Development of GUI for a typical plant.
14. Development of an alarm, and historian system for a typical process.

15. Study Modbus protocol for controller to controller communication

Instrument System Design

Teaching Scheme
Lectures: 2 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Need analysis of system requirement
- Identify circuit noise and system components
- Understand and design various noise reduction techniques.
- Select and design appropriate shielding and enclosures
- Estimate and analyze the reliability of instruments and system

Course Contents

Unit I **(08 hrs)**
Basic Concept of Instrumentation Design, Needs Analysis with respect to systems deployed in Automobile, Medical, Industrial, Agriculture, Test and Measurement, Home Appliances, Military Functional requirements & Specifications, Impact on the design due to adverse Electrical, Thermal and Mechanical Operational Environments

Unit II **(08 hrs)**
Noise sources, electrical, magnetic, RF, static, ground loops, shielding, near and far field, shielding effectiveness, absorption and reflection loss, shielding with magnetic material, contact protection, glow and arc discharges, loads with high inrush current, Inductive and resistive load contact protection networks for inductive loads, intrinsic noise sources.

Unit III **(07 hrs)**
ESD, inductive charging human body model, ESD protection in equipment, software in ESD protection, Sensitive devices, input filters, clamping suppressors. Electronic design guideline Noise in electronic circuits. Capacitive and inductive coupling and effect of shield, shielding to prevent magnetic radiation, co-axial and twisted pair cable, grounding, safety ground, signal ground, single and multi-point ground, Hybrid ground, grounding of cables shields, Ground loops and low frequency analysis of common mode signals, guard shields

Unit IV **(08 hrs)**
Enclosure Design Guidelines: NEMA, DIN, BSI, ANSI standards Index protection (IP), Cable design guidelines: Printed circuit board design guideline, layout scheme, grid systems, PCB size, Design rules for digital circuits, and Design rules for analog circuits, single and multilayer PCB, CE / Underwrites Laboratories (UL) Compliance, Reliability, bathtub curve, Reliability for series parallel system, MTTF, MTBF, MTBF, availability, Redundancy and standby systems

- ✓ Quiz / Review sessions (04) uniformly spaced out during the delivery of lecture sessions

- ✓ Homework / Project presentation
- ✓ Design of Instrument or Control system for a process.

All to submit detailed design progressively as appropriate lectures gets delivered in 5 phases:

- Needs analysis Requirement specifications & Functional specifications. At the end of unit1
- Detailed design with components at the end of unit 2,3
- Enclosure design, PCB design with wiring and layout or Control panel design instruments layout wiring in the form of P and I diagram at the end of unit 3,4
- Adherence to appropriate standards with specific clauses cited at the end of unit 4
- Reliability analysis and closure report at the end of unit 4

Text Books

- Henry OTT, "Noise reduction Techniques in Electronics Circuit", Wiley International, Second ed., 2009.

Reference Books

- Balguruswamy, "Reliability Engineering", TATA McGraw-hill Publication, Third ed., 2005
- Walter C. Bosshart, "Printed Circuit Board", Tata McGraw-Hill publication, Third ed.,2009

Instrument and System Design Laboratory

Teaching Scheme
Practical: 2 hrs./week

Examination Scheme
Continuous Assessment: 50 Marks
Practical Exam- 50 Marks

List of Experiments:

1. Design a simple instrumentation system for measuring temperature using a thermocouple. Implement a feedback control system using basic sensors and simulate its performance

2. Design a signal conditioning system for noise reduction in measured data. Build a system that filters raw sensor data using low-pass, high-pass, or band-pass filters. Visualize the signal before and after filtering.

3. Model an ESD event using a high-voltage pulse generator and observe the transient response of a sensitive circuit (e.g., a semiconductor diode) to the discharge.

4. Develop a Simulink model of the human body model for ESD (with resistance and capacitance) and simulate how static discharge from the human body can affect an electronic circuit

5. Model a system that acquires an ECG signal, applies filters, and outputs the processed signal. Include noise and interference in the signal and demonstrate filtering techniques

6. Model an industrial motor, including mechanical vibrations. Use sensors to measure vibration levels and implement a vibration control system to minimize harmful oscillations.
7. Model a system with an amplifier or sensor and introduce electrical noise sources. Simulate how noise affects the output signal, and analyze the signal-to-noise ratio (SNR)

8. Model an electrical system (e.g., sensor or power circuit) in an environment with magnetic interference. Use electromagnetic modeling to simulate how magnetic noise affects system performance

9. Build a simulation of an electrical system that includes a protection network (e.g., circuit breakers, fuses) to protect against contact faults like short circuits or overloads.

10. Model a system where an arc discharge occurs (e.g., when electrical contacts open under high current conditions) and analyze its effects on system performance, including thermal effects

11. Create a simulation of an inductive load with high inrush current and analyze the transient response. Evaluate the effect of inrush current on power supply and circuit protection devices.

Robotics and Automation

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

Perform kinematic and dynamic analyses with simulation.

1. **Design** control laws for a robot.
2. **Integrate** mechanical and electrical hardware for a real prototype of robotic device.
3. **Select** a robotic system for given application.

Course Contents

Unit I **(07 hrs)**
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.

Unit II **(07 hrs)**
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

Unit III **(08 hrs)**

Robotic sensor: Contact and Proximity, Position, Velocity, Force, Tactile, Force-Torque sensors. Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators. Vision System: Introduction to Cameras, Camera calibration,Geometry of Image formation, Euclidean/Similarity/Affine/Projective transformations, Vision applications in robotics.

Unit IV **(07 hrs)**

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 (ROS and VAL II), Applications of Industrial robot (PUMA, KUKA, FANUC, MTAB).

Unit V **(06 hrs)**

Artificial Intelligence in Robotics: Applications in unmanned systems, defense, medical, process industries, Motion planning – potential fields, projective path planning, Robotics and Automation for Industry 4.0

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).

Industrial Communication and Programming

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Understand communication network protocols and components
- Develop Operation Technology networking required for field instruments
- Program controller to automate industrial operations
- Solve problems associated with operations, networking and logic

Course Contents

Unit I **(08 hrs)**

Fundamentals of industrial data communication: Review of Data Acquisition, Automation System Architecture, Functional Layered Models - OSI reference model, Communication within systems, IEEE 802 on LAN and other Serial Protocols (RS232,RS 485 and MODBUS) Communication principles and modes, network topology, transmission media, noise, cable characteristic and selection, bridges, routers and gateways, RTUs

Unit II **(04 hrs)**

Industrial automation protocol: Modbus/TCP, EtherNet/IP, DNP, HART, OPC, PROFIBUS, PROFINET, BACnet, ICCP, MMS, Goose Messaging, WirelessHART, ISA 100, Bluetooth, Zigbee

Unit III **(08 hrs)**

Discrete operations: PLC Interfacing to AC and DC Drives/HMI/Hydraulic/Pneumatic/Motion control: Interfacing of VFD TO PLC, Interfacing to Pneumatic circuits, Interfacing to hydraulic system Introduction of Motion control, different elements in motion control, logic development for sequencing, drilling, product transfer, applications

Unit IV **(08 hrs)**

Continuous Operations: Development of Control module, equipment module, and phases for industrial operation Boiler Bioreactor and Spray dryer. Monitoring and Control of industrial operations

Unit V **(08 hrs)**

Introduction to Safety Instrumented systems: Introduction to Safety terminologies: Risk Assessment, Safety Assessment, Layers Of Protection Safety Integrity Level, Function Safety Standard IEC61508 for Systems, Functional Safety standard IEC61511 for Process Operations, HAZOP Analysis, Cause and Effect Analysis, Failure and Mode Effect Analysis, Fault Tree Analysis

Unit VI **(04 hrs)**

Safety Automation: Safety and OT Security requirements as per IEC 61511 and IEC62443

Text Books

- B. G. Liptak , "Process Control, Instrument Engineering Hand book", Chilton Book Company, Third Edition, 1995
- David J. Teumim, "Industrial Network Security, Second Edition", International Society of Automation, 2010.
- Popovic and Bhatkar , ― Distributed Computer Control For Industrial Automation‖ , Taylor & Francis group, 2011.

Reference Books

- B. G. Liptak, "Process Control, Instrument Engineering Hand book", Chilton Book Company, Third Edition, 1995

- Lawrence M. Thompson and Tim Shaw, "Industrial Data Communications", Fifth Edition, International Society of Automation, 2015.

Medical Devices

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- **Select/ identify** appropriate electrode, sensor and transducer for a physiological measurement
- **Design** different biological signal amplifiers and analysis of bio-signals
- **Identify** various blocks of biomedical equipment/ instruments
- **Define** terms used in respiratory, pathology and radiology measurements.
- **Apply** electrical safety aspects and standards in medical instruments/ equipment

Course Contents

Unit I **(08 hrs)**
Cardiovascular and neural Devices: Electrocardiograph, Electroencephalograph, Phonocardiograph, Blood pressure measurement, plethysmography

Unit II **(08 hrs)**
Therapeutic devices: Short wave diathermy, microwave diathermy, Ultrasonic Therapy unit, transcutaneous electrical nerve stimulators, radiotherapy

Unit III **(08 hrs)**
Life-saving devices: Ventilators, Pacemakers and defibrillators, Heart-lung machines
Clinical Laboratory Instruments: Electron Microscope Blood Cell Counters, Electrophoresis, Pulse oximetry, Hb and Glucose measurement, Autoanalyzer

Unit IV **(08 hrs)**
Electrical safety and related instruments: Significance of electrical danger, Physiological effects of electrical current, ground shock hazards, methods of accident prevention, Safety standards, leakage current tester, Electrical safety analyzer, Isolation techniques

(08 hrs)
Unit V
Instrumentation for Medical Imaging: X-ray, Computed Tomography, Ultrasound, Nuclear Medical Imaging, Magnetic resonance imaging, Thermal imaging

Text Books:

- Carr and Brown; "Introduction to Biomedical Equipment Technology"
- John G. Webster; "Medical Instrumentation Application and Design" John Wiley & Sons Pvt. Ltd.
- M. Arumugam; "Biomedical Instrumentation" Anuradha Publishers (1992)
- Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer; "Biomedical Instrumentation and Measurements" Pearson Education
- R. S. Khandpur; "Handbook of Biomedical Instrumentation" TMH
- Richard Aston; "Principles of Biomedical Instrumentation and Measurement "Maxwell Macmillan International Editions

- Jacobsons and Webster; “Medicine and Clinical Engineering” PHI

Industrial Internet of Things

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- To get familiar with IIOT concept and make students understand different types of Manufacturing & understanding of IS95/MOMs/ MES
- Understanding of key components of IIoT, Architectures and its pros & cons
- Understand different IIoT Business Models
- To get familiar with various Industrial IoT platforms
- Provide understanding of Privacy, Security & Governance
- Overview of Data analytics, Cloud services, IIoT Use cases & Recent Trends in IOT

Course Contents

Unit I **(10 hrs)**

Introduction to IIOT and Manufacturing Basics: Definition of IoT, Overview of Components of IIoT, Differentiation between IoT & IIoT, Differentiation between IIoT & OT, need of IIoT Evolution of IoT, Technology & Business Drivers, Business Potential of IIoT & its impact on industry, Hype Cycle, Trends**,** Business Potential of IIoT, Driving Forces of IoT. IoT Taxonomy, Business Avenues in IIoT, Benefits of IIoT, IoT Ecology. **Manufacturing Basics-** Types of Manufacturing. Purdue Enterprise Reference Architecture (PERA) Model. Basics of ISA 88 /95 Standards. Levels of Control Hierarchy. Basic Understanding of Manufacturing Execution Systems (MES) / Manufacturing Operations Managements Systems (MOMS).

Unit II **(6 hrs)**

IIoT Architecture: Characteristic of IIoT System, Basics of Plant Software Layout & Hierarchy, Basics of Web Hierarchy. Architectures for IIoT. Elements of an IIoT, types of Architectures, examples, Pros & Cons of each architectures. IOT Architecture Design Patterns, IOT System Levels, Specifications Reference Architectures and Domain Models.

Unit III **(8 hrs)**

Sensors- Sensor Basics, Role of sensors in IIoT, Applicability of Sensors in different Industries. Design of sensors, Special requirements for IIoT sensors, Sensor architecture. **Actuators basics-** Types of Actuators, **Field Networks,** Overview of wired and wireless, Topologies of Networks. **Protocols-** Overview of Protocols like ZIGBEE, ZWAVE, MBUS, 6LoWPAN, OPC-UA

Unit IV **(6 hrs)**

Different IIoT networks & connectivity, Modes of communications. Overview of various IIoT protocols like - COAP, 6LoWPAN, LWM2M, MQTT, AMPQ etc. Understanding of Edge and FOG Device Architectures. Influence of non-functional requirements on Edge and FOG devices. Edge/FOG Hardware selection criteria. Comparison of Industrial devices vs Prototype devices (Arduino, Mega, Pi, Galileo). Software Architecture of Edge/FOG devices

Unit V **(6 hrs)**

IOT Platform Architecture, Overview & Understanding of COTS cloud platforms like Predix, Watson, Thing works, Azure etc. Basic understanding of various business models like SaaS, PaaS &IaaS and pros & cons. 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.

Unit VI **(6 hrs)**

Data Analytics Basics, various techniques – M2M, CSP, Machine Learning, Deep learning, AI. Overview of IOT Cloud Services. IIoT end-to-end use cases – Asset monitoring, utilities metering (power, water, gas). Recent Trends in IOTs

Text Books

- IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things - David Hanes, Gonzalo Salgueiro& others, Cisco Press
- Industry 4.0: The Industrial Internet of Things 1st ed. Edition by Alasdair Gilchrist
- Industrial Automation and Control System Security Principles: Protecting the Critical Infrastructure, Second Edition by Ronald L. Krutz, PhD, PE

Reference Books

- 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
- Internet of things Book – A hands on Approach byBahga – Madisetti
- The Internet of Things: Key Applications and Protocols 2nd Edition - Olivier Hersent

Fundamentals of Machine Learning

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Prerequisites: Relevant applied math and statistics: probability theory, probability distribution, Conditional probability, Bayesian probabilities.

Course Outcomes:

- To introduce students to the basic concepts, tools and techniques of Machine Learning.
- To develop skills of using recent machine learning software for solving practical problems.
- Analyze and Evaluate the different ML models.
- Implement ML algorithms to solve real life problems.

Course Contents:

Unit I **(4 hrs)**
Introduction to Machine Learning: Basic concepts, Machine Learning methods: Supervised, Unsupervised, Semi-supervised, Inductive, Reinforcement Learning.

Unit II **(8 hrs)**
Linear Regression: Introduction toLinear regression, Logistic Regression, Naive Bayes Algorithm, Model Selection, Linear basis function model, model assessment, assessing importance of different variables, subset selection. Cross Validations.

Unit III **(6 hrs)**
Hypothesis Design: Types of variables, Types of measurement scales, constructing the Hypothesis, Null hypothesis, Alternative Hypothesis. Hypothesis testing, type 1 error, Type 2 error, Confidence of Interval.

Unit IV **(3 hrs)**
Instance Based Learning: Feature selection, supervised and unsupervised learning, Classification Algorithms: K-Nearest Neighbour Classification and Decision Tree.

Unit V **(7 hrs)**
Neural Network: Introduction, Feed forward network, Network training, Back propagation NN, Regularization, Error Analysis, Deep Neural Network.

Text Books

- Tom M. Mitchell, "Machine Learning", First Edition, McGraw Hill Education, ISBN 978-12-5909-695-2
- Andreas C. Müller and Sarah Guido , "Introduction to Machine Learning with Python: A Guide for Data Scientists", First Edition, O'Reilly Media, ISBN 978-14-4936-941-5

Reference Books

- Trevor Hastie, Robert Tibshirani, and Jerome Friedman, "The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Second Edition, Springer, ISBN 978-03-8784-857-0
- Christopher M. Bishop, "Pattern Recognition and Machine Learning", Second Edition, Springer, 978-03-8731-073-2
- Hadley Wickham and Garrett Grolemund, "R for Data Science: Import, Tidy, Transform, Visualize, and Model Data", First Edition, O'Reilly, ISBN 978-14-9191-039-9

Embedded Programming

Teaching Scheme **Examination Scheme**

Lectures: 3 hrs./week

Teachers Assessment (TA): 20 Marks
Mid Semester Examination: 30 Marks
End Semester Examination: 50 Marks

Course Outcomes:

- Understand the fundamentals of embedded systems and interpret technical documents.
- Understand and explain the build and development tools used in embedded systems design.
- Understand the function and program the microcontroller peripherals.
- Write interrupt service routines while using microcontroller peripherals.
- Understand RTOS internals and performance metrics.

Course Contents:

Unit I **(8 hrs)**

Introduction to Embedded Systems: What are Embedded Systems and characteristics, building blocks of Embedded Systems, various applications of Embedded Systems, Difference between Desktop Vs Embedded application development process, role of microprocessor and microcontroller in Embedded System, Understanding Block Diagram, Schematic Diagram, Datasheet, User manual, Application Notes.

Unit II **(8 hrs)**

Embedded Systems Development Tool Chain Build and development tools, Build Process, role of Linker, understanding object files, Elf Generation / Compilation/ Linker Error Resolution, tools used to extract binary code from elf, converting to different formats like plain binary, S-record, Concept of Make file and Complex Make file, Big Endian vs Little Endian, Memory mapping, understanding Startup code, Reset Code, Bootloader.

Unit III **(4 hrs)**

Microcontroller Peripherals and Programming: Understanding and programming STM32 microcontroller for GPIO, UART, Timer, PWM, ADC, UART, I2C and SPI Protocol.

Unit IV **(5 hrs)**

Microcontroller Peripheral Interrupts and Programming Interrupt Vector Table, Interrupt Priorities, Nested Interrupts, Writing ISR in assembly, and Embedded C, interrupt latency, Write interrupt service routines for various peripherals and operations.

Unit V **(7 hrs)**

Real Time Operating System: Introduction to Real-Time Concepts, RTOS Internals & Real Time Scheduling, Performance Metrics of RTOS, Task Specifications, Schedulability Analysis, Application Programming on RTOS, Configuring and Porting of RTOS.

Reference Books

- K.V.K Prasad. (2003), Embedded / Real-Time Systems: Concepts, Design and Programming Black Book, Dreamtech Press.
- STM32F401-PDFhttps://www.st.com/en/microcontrollersmicroprocessors/stm32f401/

documentation.html

- FreeRTOS Documentation: https://www.freertos.org/Documentation/00-Overview

Project Stage-II

Teaching Scheme
Practical: 4 hrs./week

Examination Scheme
Continuous Assessment: 50 Marks
Practical/ Oral Exam- 50 Marks

Course Outcomes:

- Able to apply the knowledge and skills previously gained into practice.
- Take appropriate decision with respect to various parameters related to production of a system or sub-system.
- Demonstrate the leadership quality along with ability to work in a group.
- Prove the ability to present the findings in a written report or oral presentation.

Course Contents

- Students are required to develop various modules required for their hardware and software project e.g. power supply, processor module, interfacing module, display and signal conditioning module. The PCB and enclosure design is part of the activity of this subject. Testing of various modules as per industrial standards and practices is part of the experimental work. System Design Selection of sensors, signal conditioning, standard signals and noise considerations of typical systems. Student has to develop a project which will handle and measure a physical parameter such as temperature, pressure, vibration.
- The hardware and software based project shall be carried out in-house i.e. in the department's laboratories/centres by a group 2 – 3 students. In any case the group shall not consist of more than three students.
- The hardware and software based project shall consist of design and implementation of any suitable electronic system, sub system or circuit based on knowledge and skills previously gained.
- The hardware and software based project outline on the selected topic should be submitted to the course coordinator for approval within one weeks from the commencement of the term.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation.
- Deliverables: A project report as per the specified format (available on in the department and institutes website), developed system in the form of hardware and/or software. In addition, student shall maintain a record of attendance and continuous progress (log book in appropriate format available on institute/department's web site) duly signed by course coordinator and present as mini project deliverable along with report.

Evaluation System:
It includes Internal Continuous Assessment (ICA) and End Semester Examination (ESE). Guidelines for ICA and ESE are given bellow.

Internal Continuous Assessment (ICA)

- The ICA shall be evaluated by course coordinator.
- Course coordinator shall judge the students on the principle of continuous evaluation and contribution of individual student in the group.
- It shall be evaluated on the basis of deliverables of project and depth of understanding.
- Course coordinator shall maintain the record of continuous evaluation in appropriate format available on institute/department's web site.

End Semester Examination (ESE)

- The End Semester Examination for this course shall be based on demonstration of the system or sub system developed by the group of students, deliverables of project and depth of understanding (oral examination). It shall be evaluated by two examiners out of which one examiner shall be out of institute.