College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Instrumentation and Control Engineering

Curriculum Structure & Detailed Syllabus (UG Program)

Final Year B. Tech. - F. Y. B. Tech.

(Revision: 2019-2023, Effective from 2022-23)

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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

Sr. No.	Abbreviation	Stands for:
1	BSC	Basic Science Course
2	SBC	Skill Based Course
3	IFC	Interdepartmental Foundation Course
4	PCC	Program Core Course
5	LC	Laboratory Course
6	HSMC	Humanity Science and .....Course
7	MLC	Mandatory Learning Course
8	LLC	Liberal Learning Course
9	IOC	Interdepartmental Open Course
10	DE	Department Elective

CURRICULUM STRUCTURE OF Final Year B. TECH (I & C)

(Effective from A. Y. 2022-2023)

Semester-VII [Scheme-A]

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	LLC/ LL-22001-22017	Liberal Learning Course	1	0	0	1
2	MLC/ ML-22001	Intellectual Property Rights	1	0	0	0
3	IOC/ IOC-22001-22006	Interdisciplinary Open Course-II	2	0	0	2
4	**Department Elective-II**					
	DEC/ IE(DE)-22001	Soft Computing	3	0	0	3
	DEC/ IE(DE)-22002	Building Automation				
	DEC/ IE(DE)-22003	Medical Instrumentation-I				
5	PCC/ IE-22001	Process Instrumentation and Control	3	0	0	3
6	PCC/ IE-22002	Project Engineering and Management	2	1	2	4
7	LC/ IE-22003	Process Instrumentation and Control Lab	0	1	2	2
8	SBC/ IE-22004	Seminar and Technical Writing	0	1	2	2
		Total	**12**	**3**	**6**	**17**
		Total Academic Engagement and Credits	**21**			**17**

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
Honor: Instrumentation and Control						
1	IE(HT)-21003	Robust Control	3	0	0	3
Minor: Industrial Automation						
1	MI/ IE(MI)-21005	Industrial Automation and Control	3	0	0	3
Minor: Biomedical Instrumentation						
1	MI/ IE(MI)-21006	Medical Instrumentation	3	0	0	3

Semester-VIII [Scheme-A]

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	Department Elective-III					
	DEC/ IE(DE)-22004	Batch Process Control	3	0	0	3
	DEC/ IE(DE)-22005	Vision Based Automation				
	DEC/ IE(DE)-22006	Medical Instrumentation-II				
	DEC/ IE(DE)-22007	Power Plant Instrumentation				
2	Department Elective-IV					
	DEC/ IE(DE)-22008	Embedded Systems Design Using ARM	3	0	0	3
	DEC/ IE(DE)-22009	Artificial Intelligence and Machine Learning for Process Control				
	DEC/ IE(DE)-22010	Optical Instrumentation				
3	SBC/ IE-22005	Major Project	0	0	16	8
		Total	**6**	**0**	**16**	**14**
		Total Academic Engagement and Credits	**22**			**14**

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
Honor: Instrumentation and Control						
1	IE(HT)-21004	Process Control: Design and Analysis	3	0	0	3
Minor: Industrial Automation						
1	MI/ IE(MI)-21007	Industry 4.0 and Internet of Things	3	0	0	3
Minor: Biomedical Instrumentation						
1	MI/ IE(MI)-21008	Imaging Techniques for Medical Applications	3	0	0	3

CURRICULUM STRUCTURE OF Final Year B. TECH (I & C)

(Effective from A. Y. 2022-2023)

Semester-VII [Scheme-A]

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	LLC/ LL-22001-22017	Liberal Learning Course	1	0	0	1
2	MLC/ ML-22001	Intellectual Property Rights	1	0	0	0
3	IOC/ IOC-22001-22006	Interdisciplinary Open Course-II	2	0	0	2
4	**Department Elective-II**					
	DEC/ IE(DE)-22001	Soft Computing	3	0	0	3
	DEC/ IE(DE)-22002	Building Automation				
	DEC/ IE(DE)-22003	Medical Instrumentation-I				
5	PCC/ IE-22001	Process Instrumentation and Control	3	0	0	3
6	PCC/ IE-22002	Project Engineering and Management	2	1	2	4
7	LC/ IE-22003	Process Instrumentation and Control Lab	0	1	2	2
8	SBC/ IE-22004	Seminar and Technical Writing	0	1	2	2
		Total	**12**	**3**	**6**	**17**
		Total Academic Engagement and Credits	**21**			**17**

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
Honor: Instrumentation and Control						
1	IE(HT)-21003	Robust Control	3	0	0	3
Minor: Industrial Automation						
1	MI/ IE(MI)-21005	Industrial Automation and Control	3	0	0	3
Minor: Biomedical Instrumentation						
1	MI/ IE(MI)-21006	Medical Instrumentation	3	0	0	3

Semester-VIII [Scheme-B]

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1	MOOC Course (Students have to select any one MOOC course from the list of Department Elective-III)					
	DEC/ IE(DE)-22004	Batch Process Control	3	0	0	3
	DEC/ IE(DE)-22005	Vision Based Automation				
	DEC/ IE(DE)-22006	Medical Instrumentation-II				
	DEC/ IE(DE)-22007	Power Plant Instrumentation				
2	MOOC Course (Students have to select any one MOOC course from the list of Department Elective-IV)					
	DEC/ IE(DE)-22008	Embedded Systems Design Using ARM	3	0	0	3
	DEC/ IE(DE)-22009	Artificial Intelligence and Machine Learning for Process Control				
	DEC/ IE(DE)-22010	Optical Instrumentation				
3	SBC/ IE-22005	Major Project	0	0	16	8
		Total	**6**	**0**	**16**	**14**
		Total Academic Engagement and Credits	**22**			**14**

Sr. No.	Course Type/Code	Course Name	Teaching Scheme			Credits
			L	T	P	
Honor: Instrumentation and Control						
1	IE(HT)-21004	Process Control: Design and Analysis	3	0	0	3
Minor: Industrial Automation						
1	MI/ IE(MI)-21007	Industry 4.0 and Internet of Things	3	0	0	3
Minor: Biomedical Instrumentation						
1	MI/ IE(MI)-21008	Imaging Techniques for Medical Applications	3	0	0	3

IE(DE)-22001 Soft Computing

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Able to define** the expert system architecture and artificial intelligence (AI) [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

Unit I **(07hrs)**
Artificial Intelligence: a Brief Review, Pitfalls of Traditional AI, Need for Computational Intelligence, Importance of Tolerance of Imprecision and Uncertainty, Constituent Techniques, Overview of Artificial Neural Networks, Fuzzy Logic, Evolutionary Computation.

Unit II **(08hrs)**
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.

Unit III **(07hrs)**
Fuzzy Logic: Fuzzy Sets, Properties, Membership Functions, Fuzzy Operations, Fuzzy Inference System, Fuzzification and defuzzifications module, Scaling factors, Fuzzy controllers.

Unit IV **(06hrs)**
Genetic Algorithms: Introduction and concept, Coding, Reproduction, Cross Applications, Swarm intelligence, and their applications.

Unit V **(07hrs)**
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.

IE (DE)-22002 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. [PEO-2]
- **Demonstrate and explain** HVAC, Access Control and Fire Alarm System [PEO- 2,3],
- **Devise and select** components & equipment used in these systems. [PEO-]
- **Illustrate** the integration of protocols and BMS elements for above mentioned system.

Course Contents

Unit I **(08hrs)**

Introduction Building Automation Systems, Architecture and Protocols: Intelligent building, Intelligent architecture and structure, Facilities management vs. intelligent buildings, Lifecycle of building, Evolution of intelligent buildings. Different types of subsystems in BAS which includes HVAC, access control, security, fire, lighting systems. Importance of each system in BAS. Process of BAS design, Role of different stakeholders in BAS System design. Different communication protocol and addressing concepts, in open Protocols like BACnet, LON, Profibus, Modbus, M-bus, and proprietary Protocols- N2, CBUS. Introduction to wireless – Wireless filed devices, controllers, routers, coordinators.

Unit II **(06hrs)**

Comfort parameters for human being and measurement in BMS system: Temperature, Heat, Specific Heat, Sensitive Heat & Latent Heat, Enthalpy, Entropy, Heat transfer - conduction, convection, radiation. Working principle, characteristics of different types of temperature sensors, working principle of Psychometry, working principle of different types of relative humidity sensors, different types of pressure sensors, working of principal and construction of different air flow sensors, working of principal and construction of different water flow sensors, measurement of CO2 level in air, clean air, grade of filtration, UV treatment, working principal of BTU meter.

Unit III **(8hrs)**

HVAC Basic Concepts- Systems (Air Side)- Air handling unit & Terminal Unit: 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. Design and working of different types of AHU. Operation of different modes. Concept of Variable Air Volume (VAV) system- 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 Variable Air Volume (VAV) system-Design, working, use of different types of VAV- CAV, cooling only, with reheat, series fan powered, parallel fan powered, pressure dependent, supply- exhaust VAV, and dual duct VAV. Working, use of radiation coil, chilled beam, CRAC unit, VRV systems, unit heater, Fan coil unit and unit ventilator

Unit IV **(8hrs)**

HVAC Basic Concepts- Systems (Plant Side)- Chilled water system & Hot water system: Chilled Water Systems: Concept of refrigeration cycle. Working, mechanical configuration of different types of components used in refrigeration cycle- evaporator, condenser, compressor, expansion valve. Difference between air cooled chiller and water cooled chiller. Working, mechanical configuration of different types of cooling towers. Concept and working of Absorption chiller. Concept and working of heat pump, Design, working of different types of chilled water system- single chiller system, series chiller system, parallel chiller system. Working of different components of chilled water system- de-coupler line, bypass line, primary circuit, secondary circuit, and condenser pumps. Concept of free cooling-direct waterside, series waterside, parallel waterside free cooling. Sequencing of chilled water plant

Hot water systems: Working and design of different types of boilers- fire tube, water tube, packaged boiler. Control of boiler- 7 element control, fuel-air ratio control. Working and design of different types of heat exchanger. Concept of geothermal system, Working, design of different types of hot water system- with boilers, heat exchanger with steam input, heat exchanger with hot water input, geothermal system, solar system and combination of all listed systems. Sequencing of Boiler Plant

Unit V **(6hrs)**

Access Control & Surveillance System: Introduction to Access Control system, devices, protocols in access control system, system architecture. Concept of automation in access control system for safety. Physical security system with components, RFID enabled access control with components. Computer system access control for Data Security, Data Integrity and Data Freshness. Introduction to CCTV system, Different types of cameras, Video management, Intrusion & guard tour system.

Unit VI **(6hrs)**

Fire & Alarm System: Introduction to Fire Alarm system, incorporation of comprehensive fire and life/safety systems into a building, Detection system requirement, FAS details standards & architecture, Fire suppression methods, combination of dry chemicals and/or wet agents to suppress equipment fires.

Reference Books

- Albert Ting-pat So, Wai Lok Chan, "Intelligent Building System Enhanced Edition", 1st Edition, Johnson Controls, 2009.

- Roger W. Haines "HVAC Systems Design Handbook", 5th Edition, McGraw-Hill Publication, 2015.
- James E. Brumbaugh "HVAC Fundamentals", Volume 1 to 3, 4th Edition, AUDEL, 2014.
- "Basics of Air Conditioning" ISHRAE, Indian Society of Heating, Refrigerating & Air Conditioning Engineers, 2012.

IE (DE)-22003 Medical Instrumentation-I

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Select/ identify** appropriate electrode, sensor and transducer for a physiological measurement [PO-1]
- **Design** different biological signal amplifiers and analysis of bio-signals [PO-3]
- **Identify** various blocks of biomedical equipment/ instruments [PO-2]
- **Select** biomaterials for an artificial organs/ implants [PO-2]

Course Contents

Unit I **(06hrs)**

Introduction to bio-signals and measurement: Cell structure, basic cell functions, origin of bio-potentials, electrical activity of cells, biological control concept, electrode-electrolyte interface, half-cell potential, polarizable and non- polarizable electrode, electrode circuit model, body surface recording electrodes, stimulating electrodes, various biomedical sensors, electrodes and biosensors

Unit II **(08hrs)**

Cardio-vascular system: Structure of heart, rhythmicity, pacemaker cell filters, averaging and integrator circuits, ECG signal acquisition, analysis and representation of vari, ECG theory, ECG electrodes, electrocardiograph, vector cardiograph, ECG analysis, Bio-signal amplifiers and signal processing, transient protection, isolation circuit, interference reduction circuits, active ous ECG disorders

Unit III **(08hrs)**

Central nervous systems and muscular system: Receptors, sensory pathways and motor systems, processing sensory information, neural, neuromuscular, sensory muscular and sensory measurements, biofeedback, evoked response, electroencephalography (EEG), EEG amplifier, separation of alpha, beta, theta and delta waves from EEG. Classification of muscles – muscle contraction mechanism, myoelectric voltages, electromyography (EMG), noise removal and signal compensation for reducing ECG artefacts in an EMG recording.

Unit IV **(07hrs)**

Cardiovascular measurements, therapeutic devices and life saving devices: Heart sound, phonocardiography, PCG analysis to diagnose heart valve disorder, blood pressure measurement (invasive and non-invasive), blood flow meter-magnetic and ultrasound, cardiac output measurement, plethysmography, Short wave diathermy, microwave diathermy, ultrasound therapy unit, transcutaneous electrical nerve stimulators, radiotherapy, Pacemakers and defibrillators, heart lung machine.

Unit V **(08hrs)**

Auditory and vision system: Mechanism of hearing, sound conduction system, basic audiometer, pure tone audiometer, audiometer system bekesy, evoked response audiometer system, hearing aids. Anatomy of eye, visual acuity, slit lamp, tonometer, ophthalmoscope, perimeter, LASER applications in ophthalmology – diabetic retinopathy, glaucoma and retinal hole and detachment treatment.

Unit V **(08hrs)**

Biomaterials: Structure and property relationships in materials, biocompatibility, metallic, ceramics, polymers, composite materials, biodegradable polymeric material, biologic biomaterials, interactions of materials with the human body: concepts and applications, case study: Bionic eye and ear

Reference Books

- Leslie Cromwell, Fred J. Weibull, Erich A. Pfeiffer, "Biomedical Instrumentation and Measurements", Pearson Education, 2nd ed. 1980.
- R. S. Khandpur, "Handbook of Biomedical Instrumentation", TMH, 2nd ed., 2008
- Vander, Shermen, "Human Physiology" – The Mechanism of Body Functions", TMH, 13th ed., 2013.
- Tompkins, "Biomedical Digital Signal Processing", PHI, 5th ed., 2010
- John G Webster, "Encyclopedia of Medical Devices and Instruments", Wiley Publications, 1988.
- M. Arumugam, "Biomedical Instrumentation", Amerada Publishers, 2nd ed., 1992
- Carr and Brown "Introduction to Biomedical Equipment Technology", Pearson LPE, 4th ed., 2001.
- Richard Aston, "Principles of Biomedical Instrumentation and Measurement", Maxwell Macmillan, International ed., 1990.
- John G. Webster, "Medical Instrumentation Application and Design", John Wiley& Sons Pvt. Ltd, 3rd ed., 2009

IE-22001 Process Instrumentation and Control

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Identification** of the process and its model. [PEO-1], [PO2]
- **Understanding** and tuning of various control schemes [PEO-1], [PO-2]
- **Designing** of multivariable scheme [PEO-2], [PO3]
- **Applications** of various control techniques to Processes [PEO-3], [PO4]

Course Contents

Unit I **(07hrs)**

Introduction to process: Review of types of processes, dead time, capacity, process reaction curve, process time constant & constant step analysis method for finding time constant, Introduction to Statistical Process Controls

Unit II **(09hrs)**

Control System: Feedback control, Feed Forward control, Ziegler–Nichols tuning technique, Cohen-Coon tuning technique, Adaptive PID control, Cascade Control, Ratio Control, Selective Control, Split-range Control, LQR Control

Unit III **(06hrs)**

Modeling of Process: General modeling principles; degrees of freedom analysis, State variables, State equations, Lumped and distributed parameter system, Analysis of transfer function model, Steady state and dynamic behavior, Empirical model

Unit IV **(06hrs)**

System Identification: Identification of physical processes, online and offline identification, various test signals and its application, Overview of various tools used to identify process model

Unit V **(05hrs)**

Multivariable and Multiloop control: Interaction and its effect, Decoupling methods, Relative Process Gain Matrices (RPG) & applications, Stability of multi-loop control system, Model Predictive Control

Unit V **(09hrs)**

Control Schemes for Process Applications: Development of control schemes for continuous-time process, discrete-time process and batch processes applications.

Text Books

- F. G. Shinskey, "Process Control System", 1st Edition, McGraw Hills Publication, 1996.
- B. G. Liptak , "Process Control", 4th Edition, Chilton Publications, 2009.
- F. G. Shinskey, "Feedback controllers: Tuning, Applications & Design", 4th Edition, McGraw-Hill, 1998.

Reference Books

- G. Stephanopolous, "Chemical Process Control", 5th Edition Prentice Hall of India, 2001.
- Douglas M. Considine, "Process Instrumentation and control Handbook", 1st Edition, McGraw-Hill, 1984

IE-22002 Project Engineering and Management

Teaching Scheme	Examination Scheme
Lectures: 3hrs./week	T1 and T2: 10 Marks each
Tutorial: 1 hr /week	End-Sem Exam: 30 Marks
Practical: 2 hrs/week	Practical & Viva: 50 Marks

Course Outcomes:

- **Know** the role and responsibilities in the project organization structure [PEO-4][PO-9, 10]
- **Learn** the tools of Project Planning scheduling and planning [PEO-3,4][PO-6,11]
- **Apply** the design documents/activities require in different phases of the project. [PEO-4][PO-3,5]
- **Understand/ apply** the standards in the project development [PEO-2,3][PO-3,9]
- **Interpret** the design information from the documents [PEO-4][PO-6, 12]

Course Contents

Unit I **(07hrs)**

Definition and objectives of Project Management, Types and classification of projects, Life cycle phases of the project. Interactions involved in Project and their coordination. Organization Structure: Role and responsibilities of the project manager, functional team members. Management functions: Defining the scope, team building, controlling, directing

Unit II **(07hrs)**

Project Planning: Introduction and basic requirements, establishing project objectives, Statement of work (SOW), project specifications, Work Breakdown structure (WBS). Project scheduling: Introduction and basic requirements, milestone scheduling, Network scheduling techniques: Network fundamentals, PERT, CPM, concept of crash time. Types of estimates, pricing process.

Unit III **(08hrs)**

Introduction to ISA standards: ISA S-5.1, 5.2, 5.3, 5.4, 5.5 and S-20. Preliminary Engineering Documents: PFD, P&ID (ISA S-5.1, 5.3), Process Control Narratives. Front End Engineering and Design (FEED) documents: Plant and piping layouts, Instrument schedule, I/O schedule, Instrument specification sheets (ISA S-20), logic diagram (ISA S-5.2), sizing and calculation documents, Instrument layout, Junction box layout, Cabling and network layout diagrams, Control room layouts, software's used in project Management, Personal Management Skills. Risk Management.

List of Experiments:

Students are expected to perform Minimum Eight Experiments:

1. Develop SOW, project specifications and WBS for any instrumentation project.
2. Preparation of Inquiry, Quotation, Comparative statement, Purchase orders.
3. Study of standards and symbols (ANSI / ISA S-5.1).
4. Development of Process & Instrument diagram of typical process.
5. Develop Instrument index sheet for a P&ID developed in experiment 4.
6. Develop specification sheets for transmitters and actuators (ISA S-20 Format).
7. Prepare a loop wiring diagram and Cable schedule.
8. Prepare a Hook up drawings for installation of transmitters and control valve.
9. Develop GA and mimic diagram of a control panel.
10. Prepare documents required for FAT of a control panel.

Text Books

- W.G. Andrew and H.B. Williams, "Applied instrumentation in process industries" Gulf Professional Publishing, 3rd ed. 2008.
- Harlod Kerzner and Van Nostrand, "Project management: A systems approach to planning scheduling and controlling" Reinhold Publishing, 11th ed., 2010.

Reference Books

- Michael D. Whitt, "Successful Instrumentation & Control Systems Design", 2nd Edition, ISA Publisher, 2012,

- Tapan B. Bagchi, "ISO- 9000 Concepts, Methods & Implementation", 1st Edition, Wheeler pub., 1995.
- Bela G Liptak, "Instrument Engineers Handbook: Process Control", CRC Press, 3rd Edition, 1995.

IE-22003 Process Instrumentation and Control Laboratory

Teaching Scheme
Practical: 2hrs./week

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

Course Outcomes:

- An ability to **design and conduct** experiments for process characteristics identification, collect the data from the system and interpret the classification of the system [PEO1][PO-2]
- An ability to **identify**, control loop in a given process and apply appropriate control strategy [PEO1][PO-3]
- An ability to **select and use** latest hardware and software tools for various processes and systems [PEO2][PO-4]

List of Experiments:

1. Study and analysis of flow, pressure, and level control loop (Analysis includes process parameters such as type of process, dead time, capacity etc.)
2. Design open loop and close loop control for the given plant.
3. Design a closed loop PID control using Ziegler Nichols tuning method.
4. Design a closed loop feed forward controller for the given plant.
5. Design a closed loop cascade control for the given plant.
6. Development of mathematical model using first principle method.
7. Development of mathematical model using system identification technique.
8. Design and development of a scheme to understand interaction between the loops.
9. Design and development of decoupling system to remove interaction
10. Design and development of LQR control for linear plant model
11. Design and development of MPC control for linear/ nonlinear plant model

IE-22004 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. [PEO-4,3][PO-9, 10]
- **Analyze** alternative approaches, apply and use most appropriate one for feasible solution. [PEO-1,2] [PO-3,4]
- **Present** seminar and **Write** precise technical reports in a nutshell. [PEO-2] [PO-7,11]
- **Participates** effectively in multi-disciplinary and heterogeneous teams exhibiting team work, Inter-personal relationships, conflict management and leadership quality. [PEO-5] [PO-10, 12]

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.

IE(HT)-21003 Robust Control

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Revise the knowledge** on the characteristics of nonlinear systems
- **Design and analyze** sliding mode controller for uncertain systems
- **Demonstrate** capability to design estimators for state and uncertainty estimations.
- **Ability to design** different controller using discrete domain using delta operator

Course Contents

Unit I **(7hrs)**
Introduction to uncertain systems, Nonlinear system, Feedback linearization. Lyapunov stability theory. Stability definition, stability of linear systems, Construction of Lyapunov function, Lyapunov linearization method, Design of controllers for nonlinear systems.

Unit II **(6hrs)**
Sliding mode control, chatter control, Simple Sliding mode control design, Sliding mode control for linear system

Unit III **(7hrs)**
Sliding mode control based on reaching law, Robust Sliding mode control based on reaching law, Quasi sliding, Reaching phase elimination

Unit IV **(8hrs)**
Different methods of reaching phase elimination, Sat function for reaching phase elimination, invariance and matching conditions Mismatch systems, Backstepping technique, Model following control, Model following Sliding mode control

Unit V **(6hrs)**
Shift operator and delta operator, Discrete sliding mode control, Unified sliding condition, Unified sliding mode theory Methods of uncertainty estimation, time delay control, inertial delay control,

Unit V **(6hrs)**
State observers, Simultaneous state and uncertainty observers, Extended state observer, disturbance observers, Some case studies, Adaptive sliding mode control

Reference Books

- C. Edwards and S.K. Spurgeon, "Sliding Mode Control: Theory and Applications", Taylor & Francis, 1998.
- G. Bartolini, L.Fridman, A. Pisano and E. Usai (Ed.), "Modern sliding mode control theory", Springer, 2008. 3. J.J.E Slotine and W. Li, "Applied nonlinear control", Prentice Hall, 1991.
- Slotine and W.LI, "Applied Nonlinear Control", 1st Edition, Prantince Hall, Engloe wood NewJersey 1991.

IE (MI)-21005 Industrial Automation and Control

Teaching Scheme
Lectures: 3 Hrs/week

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

Course Outcomes

- Examine hierarchy of Industrial Automation[PEO1] [PO-1]
- Solve the problem in control network[PEO1] [PO-3]
- Demonstrate functions of distributed control system[PEO5] [PO-5]
- Develop data historian using distributed control system[PEO5] [PO-6]
- Apply data analytics tool[PEO2] [PO-4]

Unit I **(08Hrs)**

Introduction and evolution of Automation, Elements of process control loop, concept of process variables, set point, controlled variable, manipulated variable, load variable. Examples of process loops like temperature, flow, level, pressure

Unit II **(08Hrs)**

Introduction to transmitters, Types, working principle and block schematic, Need for standardization of signals, current, voltage and pneumatic signal standards, calibration setup, Application of transmitter for level measurement, I/P converter, P/I converter working principle and calibration procedure.

Unit III **(08Hrs)**

An introduction to network, overall fieldbus trends, Instrumentation Network Design, Fieldbus advantages and disadvantages, HART Network, Foundation Fieldbus Network, Modbus TCP/IP

Unit IV **(08Hrs)**

Introduction to Distributed Control System, Functional level, data base organization, Operator interface, Introduction to Object Linking and Embedding (OLE) for Process Control, Historical Data storage

Unit V **(06Hrs)**

Integration of PLC, DCS , HMI and SCADA, Integration with RTU's, fieldbus and data highway, introduction to knowledge based software: performance monitoring like insight, Asset Management software

Unit V **(06Hrs)**

Data Analytics tools, historian sizing, features extraction, feature selection correlation analysis, principle component analysis, entropy, data labelling, Machine learning approaches: parametric and nonparametric model

Text Books:

- Dobrivoje Popovic, "Distributed Computer Control for Industrial Automation", Marcel Dekker, 1990
- B. G. Liptak, "Process Software and Digital Networks", CRC Press. Third Edition 2000
- B. G. Liptak , "Process Control, Instrument Engineering Hand book", Chilton Book Company, Third Edition, 1995

IE (MI)- 21006 Medical Instrumentation

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
Test-I-20, Test-II-20
End-Sem Exam- 60 Marks

Course Outcomes:

- Identify and select of electrodes, sensors and transducers for physiological measurement of bio-signals
- Design of signal acquisition modules and analysis of bio-signals
- Study and Identify various modules of medical instruments / equipment
- Selection of biomaterials for a typical application

Unit I:Bio-potential measurement (06 hrs)
Cell structure, basic cell functions, origin of bio-potentials, electrical activity of cells, biological control concept, electrode-electrolyte interface, half-cell potential, polarizable and non-polarizable electrode, body surface recording electrodes, stimulating electrodes, various biomedical sensors, electrodes and biosensors

Unit II: Cardio-vascular system (08 Hrs)
Structure of heart, rhythmicity, ECG theory, ECG electrodes, electrocardiograph, ECG analysis, Bio-signal amplifiers and signal processing, ECG signal acquisition, analysis and representation of various ECG disorders, Heart sound, phonocardiography

Unit III: Central nervous systems and muscular system (08 Hrs)
Receptors, sensory pathways and motor systems, processing sensory information, neural, neuromuscular, sensory muscular and sensory measurements, biofeedback, evoked response, electroencephalography (EEG), EEG amplifier, EEG signal acquisition & analysis, Classification of muscles, electromyography (EMG),

Unit IV: Auditory and vision system (08 Hrs)
Mechanism of hearing, sound conduction system, basic audiometer, pure tone audiometer, audiometer system bekesy, evoked response audiometer system, hearing aids. Anatomy of eye, visual acuity, slit lamp, tonometer, ophthalmoscope, perimeter, LASER applications in ophthalmology – diabetic retinopathy, glaucoma and retinal hole and detachment treatment.

Unit V: Therapeutic devices and life saving devices (07 Hrs)
Short wave diathermy, microwave diathermy, ultrasound therapy unit, transcutaneous electrical nerve stimulators, radiotherapy, Pacemakers and defibrillators, heart lung machine, Biomaterials.

Unit VI: Clinical lab Instrumentation (06 Hrs)
Blood and its composition, blood functions, electron microscope, blood cell counters, electrophoresis, pulse oximetry, haemoglobin measurement, glucose measurement-invasive and non-invasive, auto analyser.

Text Books:

- Leslie Cromwell, Fred J. Weibull, Erich A. Pfeiffer, "Biomedical Instrumentation and Measurements", Pearson Education, 2nd ed. 1980.
- R. S. Khandpur, "Handbook of Biomedical Instrumentation", TMH, 2nd ed., 2008.

Reference Books:

- Vander, Shermen, "Human Physiology" – The Mechanism of Body Functions‖, TMH, 13th ed., 2013.
- Tompkins, "Biomedical Digital Signal Processing", PHI, 5th h ed., 2010
- John G Webster, "Encyclopaedia of Medical Devices and Instruments", Wiley Publications, 1988.
- M. Arumugam, "Biomedical Instrumentation", Amerada Publishers,2nd ed., 1992
- Carr and Brown "Introduction to Biomedical Equipment Technology", Pearson LPE, 4th ed., 2001.
- Richard Aston, "Principles of Biomedical Instrumentation and Measurement", Maxwell Macmillan, International ed., 1990.
- John G. Webster, "Medical Instrumentation Application and Design", John Wiley& Sons Pvt. Ltd,3rd ed., 2009.

IE (DE)-22004 Batch Process Control

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Understanding** batch process terminologies, operation[PEO5][PO1]
- **Acquired knowledge** of standards used for batch process control [PEO5][PO4]
- **Development** of control schemes for different batch process application[PEO5][PO2]

Course Contents

Unit I **(6hrs)**

Introduction: Introduction to batch control system, batch control system terminology, characteristics of batch processes, hierarchical batch model, control structure for batch systems.

Unit II **(6hrs)**

Batch Control System: Terminology, Typical Functions 'Interlocking, Calculations, Batch Sequence control (Heating-Mixing-transfer), Scheduling and tracking of multiple units, Adjusting set points', HW & SW challenges, Equipment, Process actions.

Unit III **(7hrs)**

S88 Standard: Need for standards, Batch Control Language Requirements, FDA Validation, Code of Federal Regulations (CFR), Good Manufacturing Practice, GAMP Life Cycle, Compliance to 21 CFR Part 11, Introduction to S88 standard, S88 Models, Physical model, Control activity model, Procedural control model, Process model, advantages of S88 standard

Unit IV **(6hrs)**

S95 Standard: Need for S95 Standard, Hierarchical and Functional Model, Object Model Attributes, Models of Manufacturing Operations Management, Business to manufacturing transactions

Unit V **(7hrs)**

Design of batch control systems: Batch Management Model and its Functions, Recipe Management, Recipe Classifications, Recipe Structure, Information/display requirements, cost justification and benefits, data management.

Unit VI **(10hrs)**

Batch Control System Implementation, and case studies: Batch Control System Requirements, Specifications, Design, System Hardware and Reliability Requirements, Batch Control System Implementation, case study of batch control system implementation for applications in food and beverages, pharmaceuticals

Text Books

- Thomas.G. Fisher William M. Hawkins, "Batch Control Systems", ISA series, 1 st ed., 2008.

IE (DE)-22005 Vision Based Automation

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Introduction** of Acquisition of image and its processing. [PEO-1] [PO-2]
- **Selection** of sensor for the application [PEO-2], [PO-3]
- **Application** of various control techniques to Processes [PEO-3], [PO4]

Course Contents

Unit I **(7hrs)**

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.

Unit II **(7hrs)**

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

Unit III **(7hrs)**

Image Analysis: Pixel value analysis, Morphology Analysis, Quantitative analysis, Shape and pattern matching, Character recognition, Image focus quality

Unit IV **(7hrs)**

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

Unit V **(7hrs)**

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)

Unit V **(9hrs)**

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, 1st edition, 1996.
- Pascal Bornet, lan Barkin, Dr. Jochen Wirtz , "Intelligent Automation", Kindle Edition.

IE (DE)-22006 Medical Instrumentation-II

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- To **define** terms used in respiratory, pathology and radiology measurements [PO-1]
- To **design and realization** of various blocks of medical instruments/ equipment [PO-3]
- **Apply** electrical safety aspects and standards in medical instruments/ equipment [PO-2]
- **Apply** knowledge of mathematics, science and materials to orthotics and prosthetic devices. [PO-2]

Course Contents

Unit I **(6hrs)**

Respiratory instrumentation: Natural process of breathing, O2 and CO2 transport, regulation of breathing, ventilator terms, spirometer, airflow measurement, oxygenators-bubble type, membrane type, gas analysers, ventilators.

Unit II **(6hrs)**

Clinical lab Instrumentation: Blood and its composition, blood functions, electron microscope, blood cell counters, electrophoresis, pulse oximetry, haemoglobin measurement, glucose measurement-invasive and non-invasive, auto analyser.

Unit III **(8hrs)**

Operation Room Instrumentation: Electrosurgical unit, anaesthesia machine, operation table, autoclave, elements of intensive care unit, bedside monitor, drug delivery system, lithotripsy, ICU layout, introduction to telemetry and telemedicine.

Unit IV **(6hrs)**

Electrical Safety: Significance of electrical danger, physiological effects of electrical current, ground shock hazards, methods of accident prevention, safety standards-IEC, leakage current measurement techniques, electrical safety analyser.

Unit V **(8hrs)**

Concept of Rehabilitation Engineering: Skeletal system, overview of biomechanics, GAIT analysis, orthotics and prosthetic devices, overview of various orthotics and prosthetic devices materials, wheelchair – types, materials used in wheelchair, Brain Computer Interface based wheelchair, artificial organ – artificial kidney.

Unit V **(8hrs)**

Imaging Systems: X- rays, image intensifiers, CT scanner, ultrasound scanner, nuclear methods, thermography, MRI, fusion imaging, artifacts, introduction to image processing.

Reference Books

- Leslie Cromwell, Fred J. Weibull, Erich A. Pfeiffer, "Biomedical Instrumentation and Measurements", Pearson Education, 2nd ed. 1980.
- R. S. Khandpur, "Handbook of Biomedical Instrumentation", TMH, 2nd ed., 2008
- Vander, Shermen, "Human Physiology" – The Mechanism of Body Functions", TMH, 13th ed., 2013.
- Tompkins, "Biomedical Digital Signal Processing", PHI, 5th ed., 2010
- John G Webster, "Encyclopedia of Medical Devices and Instruments", Wiley Publications, 1988.
- M. Arumugam, "Biomedical Instrumentation", Amerada Publishers, 2nd ed., 1992
- Carr and Brown "Introduction to Biomedical Equipment Technology", Pearson LPE, 4th ed., 2001.
- Richard Aston, "Principles of Biomedical Instrumentation and Measurement", Maxwell Macmillan, International ed., 1990.
- John G. Webster, "Medical Instrumentation Application and Design", John Wiley& Sons Pvt. Ltd, 3rd ed., 2009

IE (DE)-22007 Power Plant Instrumentation

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Acquire knowledge** of Instrumentation utilized in power plant
- **Demonstrate** the standards/knowledge necessary for pursuing a professional career
- **An ability** to identify, control loop in a power plant process and apply appropriate control strategy
- **Understand** the impact of Instrumentation and Control solution to power industry in environmental and societal context

Course Contents

Unit I **(8hrs)**

Energy sources, their availability, worldwide energy production, energy scenario of India. Introduction to Power generation: Classification: Renewable and non-renewable energy generation resources. Renewable: Small Hydro, modern biomass, wind power, solar, geothermal and bio-fuels. Nonrenewable: fossil fuels (coal, oil and natural gas) and nuclear power.

Unit II **(9hrs)**

Thermal Power Plant: Method of power generation, layout and energy conversion process, material handling systems.

Boiler Instrumentation and Control: Boiler types, Boiler control schemes as: Combustion control, air to fuel ratio control, 3-element drum level control, steam temperature and pressure control, oxygen/CO2 in flue gases, furnace draft, boiler interlocks, burner management systems and controllers, water treatment, electro-static precipitator, soot blower, economizer, de aerator, super heater, chemical dosing systems, air pre-heater, coal and ash handling systems, fuel storage and distribution. Start-up and shut-down procedures, Boiler safety standard, Boiler inspection procedures. Boiler load calculation, boiler efficiency calculation

Unit III **(6hrs)**

Turbine Instrumentation: Turbine Instrumentation and Control, Start-Up and Shut-Down, Thermal Stress Control, Turbine Supervisory Instrumentation, Condition Monitoring, Generator, Power Distribution Instrumentation

Unit IV **(6hrs)**

Nuclear Power Plant Instrumentation: Classification of Nuclear Reactors, Nuclear Reactor Control Loops, Fuel Cycle, Power flow control, Pressure Sensing Line Dynamics, On-Line Detection of Sensing Line Problems and safety instrumentation, reliability aspects and various modes of operations.

Unit V **(8hrs)**

Non-Conventional Energy System: Solar Cell, Manufacturing Technologies - Amorphous, Monocrystalline, Polycrystalline, V-I Characteristics of a PV Cell, PV Module, Array, Maximum Power Point Tracking (MPPT) Algorithms. Wind Power: Types of Wind Mills, Wind Turbine Aerodynamics Fuel cell: Principle of Fuel cell, Types of Fuel cell, performance limiting factors of fuel cells, application of fuel cell Geothermal: resources for geo-thermal energy, application of geothermal energy, advantages and limitation of geothermal energy

Unit VI **(6hrs)**

Smart Grid Infrastructure

Introduction Smart Grid, Micro Grid, Home Automation Networks (HANs), Automatic Metering Infrastructure (AMI), Substation Automation, Remote monitoring, Energy storage management.

Text Books

- David Lindsley, "Boiler Control Systems", 1st Edition, Mc-Graw Hill Publication, 2001.
- P.K.Nag, "Power Plant Engineering", 3rd edition, McGraw Hill Publication, 2010
- K. Krishnaswamy, M. PonniBala, "Power Plant Instrumentation", 1st Edition, PHI Learning Pvt. Ltd., 2011,.

Reference Books

- Sam. G. Dukelow, "The Control of Boilers", 2nd ed., ISA Press, New York, 1991.
- Manoj Kumar Gupta, "Power Plant Engineering", 1st Edition, PHI Learning Private Limited, 2012.
- G.S. Sawhney, "Non-Conventional Energy Resources", 1st Edition, PHI Learning Private Limited, 2012
- Gill A.B, "Power Plant Performance", 1st Edition, Butterworth, London, 1984.

IE (DE)-22008 Embedded System Design Using ARM

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Understanding** the RISC architecture of processor, its features and applications.
- **Understanding** of ARM cortex-M series architecture.
- **Working** with STM32F4XX series microcontroller
- **Understanding and development** of on-chip and external interfaces
- **Study, design, analyze** of various ARM based embedded application.

Course Contents

Unit I **(6hrs)**

Embedded Systems Fundamentals: Introduction to embedded systems, classification and design considerations of embedded systems, Microprocessor and Microcontroller fundamentals, applications and development tools.

Unit II **(8hrs)**

ARM-Cortex M Series Architecture: ARM 32-bit microcontroller architecture—technology overview, Architectural Features of ARM Cortex M series (STM32F4XX series): Block Diagram, CPU modes, register organization, ROM, RAM, data and address bus, Memory mapped I/O and I/O mapped I/O. CISC Vs RISC design philosophy, Von-Neumann Vs Harvard architecture, instruction set, pipelining, exceptions, and its handling.

Unit III **(6hrs)**

STM32F4XX Development Tools: ARM, STM32F4XX series architecture details, about Nucleo or discovery development board, working with CubMX and IDE's (Keil or IAR). I/O programming, LED, switch interfacing, LCD interfacing.

Unit IV **(8hrs)**

STM32F4XX- On chip Features: STM32F4XX series on chip features: Timers, and timers programming, PWM and Interrupt programming. On-chip ADC and ADC programing. DAC programming.

Unit V **(8hrs)**

STM32F4XX- On chip Communication Features: STM32F4XX series on chip features: Synchronous and Asynchronous communication, on-chip USB, OTG, interfacing, I2C, SPI and CAN interfaces.

Unit VI **(6hrs)**

Embedded System Applications: IoT applications, Home automation, simple alarm system, touch screen and HMI, blue tooth and wi-fi interfaces and applications.

Text Books

- Sloss Andrew N, Symes Dominic, Wright Chris, "ARM System Developer's Guide: Designing and Optimizing", 1st Edition, Morgan Kaufman Publication, 2004.
- Michael Beck, "Linux kernel programming", 3rd Edition, Addison-Wesley Professional, 2002.
- Jonathan W Valvano, "Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers", 3rd Edition, Create space publications, 2014. ISBN: 978-1463590154.
- Jonathan W Valvano, "Embedded Systems: Introduction to ARM Cortex-M Microcontrollers", 5th edition, Create space publications, 2010. ISBN-13: 978-1477508992

Reference Books

- Raj Kamal, "Embedded Systems – Architecture: Programming and Design", 2nd Edition, Tata McGraw-Hill Education, 2003.

IE (DE)-22009 Artificial Intelligence and Machine Learning for Process Control

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

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

Course Contents

Unit I **(4hrs)**

Artificial Intelligence (AI) Fundamentals, defining AI techniques.

Unit II **(10hrs)**

Introduction to Machine Learning, classification of Machine Learning algorithms, regression and classification, Linear regression (Simple and Multiple), Logistic regression, Decision tree(Regression and classification), SVM, K means Clustering, Hierarchical Clustering, KNN Classifier.

Unit III **(8hrs)**

Supervised, unsupervised and semi-supervised learning, Algorithms. Concepts, instances and attributes, training and testing data, Libraries for ML.

Unit IV **(6hrs)**

Gradient descent algorithm, cost function, Activation functions, data preprocessing and transformation techniques.

Unit V **(8hrs)**

Applications of ML to Process Control, Development of Models- Black-box, Gray box and white box models, model validations with physics based models, system identification. Development of Data based controls

Unit VI **(6hrs)**

Data based Controls and ML based controls for Process Control Applications.

Text Books and Reference Books

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

IE (DE)-22010 Optical Instrumentation

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Acquire** the knowledge of system of units, classification and essentials of measuring instruments
- **Design** the construction and operation of various measuring instruments.
- **Identify** the measuring instruments and apply them for quantifying measurements of parameters.
- **Analyze** and select proper optical measuring instrument for given application

Course Contents

Unit I **(8hrs)**

Light Sourcing, Transmitting and Receiving: Concept of light, classification of different phenomenon based on theories of light, basic light sources and its characterization, polarization, coherent and incoherent sources, grating theory, application of diffraction grating, electro-optic effect, acousto-optic effect and magneto-optic effect.

Unit II **(8hrs)**

Opto–Electronic devices and Optical Components: Photo diode, PIN, photo-conductors, solar cells, phototransistors, materials used to fabricate LEDs and lasers design of LED for optical

communication, response times of LEDs, LED drive circuitry, lasers classification (ruby lasers, neodymium lasers, CO2 lasers, dye lasers, semiconductors lasers,) lasers applications.

Unit III **(8hrs)**

Interferometry: Interference effect, radiometry, types of interference phenomenon and its application, michelson's interferometer and its application, refractometer, rayleigh's interferometers, spectrographs and monochromators, spectrophotometers, calorimeters, medical optical instruments

Unit IV **(8hrs)**

Optical Fiber Sensors: Active and passive optical fiber sensor, intensity modulated, displacement type sensors, multimode active optical fiber sensor (micro bend sensor) single mode fiber sensor-phase modulates and polarization sensors

Unit V **(8hrs)**

Fiber optic fundamentals and Measurements: fundamental of fibers, fiber optic communication system, optical time domain reflectometer (OTDR), time domain dispersion measurement, frequency domain dispersion measurement

Text Books

- John M. Senior, "Optical fiber communications", 2nd edition, Pearson Publications, 2012.
- Gerd Keiser, "Optical fiber communications", 4th edition, Tata McGraw Hill Pub, 2018.
- Vivekanand Mishra and Sunita P. Ugale, "Fiber Optic Communication- Systems and Components", 2nd edition, Wiley-India Pub, 2010.
- Nityanand Chaudhary and Richa Verma, "Laser Systems and Applications", 1st Edition, PHI Learning Pvt. Ltd., 2011.

Reference Books

- John M. Senior, "Optical Fiber Communications Principles and Practice", 2nd Edition, PHI publication, 2008
- Ed. Jose Miguel Lopez-Higuera, "Optical Fiber Sensing Technology", 1st Edition, John Wiley & Sons, 2002
- S. C. Gupta, "Optoelectronic Devices and Systems", 1st Edition PHI Publication, 2010

IE-22005 Major Project

Teaching Scheme
Practical's: 16 hrs./week

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

Course Outcomes:

- Ability to **work effectively** in a proposed project team (may be multidisciplinary teams) [PEO-4,3][PO-9, 10]
- Ability to **implement** the principles and practices for instrument / system / equipment / device design and development to real world problems adhering to safety and regulatory standards as applicable [PEO-1,2] [PO-3,4]

- **Understand** the impact of Instrumentation and Control solutions in a global, economic, environmental and societal context [PEO-2] [PO-7,11]
- **Prove the ability** to present the findings in a written report or oral presentation [PEO-5] [PO-10, 12]

Course Contents

Literature review to understand current technological development, study, analysis, design, fabrication, testing and calibration of a typical instrumentation and control based process, documentation based on the above mentioned parameters as a final project report.

Internal Continuous Assessment (ICA)

- The ICA shall be evaluated twice in the semester. A committee comprising of three examiners (one of them should be guide) nominated by head of department, will take the review of the project work twice in a semester. Committee shall judge the students on the principle of continuous evaluation and contribution of individual student in the group. Average of two reviews shall be considered as overall performance of the student.
- 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 with suggested rubrics.

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.

IE(HT)-21004 Process Control: Design and Analysis

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Identification** of different process model [PEO-1], [PO-2]
- **Implementation** various control schemes for different processes using advanced control methods. [PEO-2], [PO-3]
- **Analysis** of the controller performance for the given inputs [PEO3], [PO-4]

Course Contents

Unit I **(8hrs)**

Process Modeling: Types of models and modeling methods, modeling of process control systems in time domain and frequency domain, Stability

Unit II **(6hrs)**

Controller design, tuning and analysis: Controller equations, analysis of closed loop transfer functions, Stability analysis of closed loop control methods

Unit III **(6hrs)**

System Identification and application: Techniques Identification of physical processes, off-line and on-line identification, step testing, pulse testing, sine wave testing, review of system identification tools

Unit IV **(6hrs)**

Multivariable control Analysis: Multivariable system, MIMO, degree of freedom, Liapunov stability system, interaction and decoupling, design of control system for multivariable system, RGA, Design of Non interacting control loops.

Unit V **(6hrs)**

Control and its applications: Cascade control, ratio control, selective control, split Range control, adaptive control techniques, model predictive control.

Unit VI **(8hrs)**

Controller performance diagnosis methods: Various methods of stability analysis, controller performance analysis, Controller response to various inputs and disturbances

Text Books

- F. G. Shinsky, "Process Control System", 1st Edition, McGraw Hills Publication, 1996.
- B. G. Liptak , "Process Control", 4th Edition, Chilton Publications, 2009.
- Babatunde Ogunnaike and W. Harmon Ray, "Process Dynamics, Modeling, and Control", 1st Edition, Oxford University Press, 1994. ISBN-13: 978-0195091199 ISBN-10: 0195091191

Reference Books

- Andrews and Williams, "Principles of Applied instrumentation", Vol. I, II, III, IV, Gulf Publications company, 1994.
- Popovic and Bhatkar, "Distributed Computer Control For Industrial Automation", 1st Edition, Taylor & Francis group, 2011.
- S. K. Singh, "Process Control Concepts, Dynamics and Applications", 1st Edition, PHI Publications, 2009

IE(MI)-21007 Industry 4.0 and Internet of Things

Teaching Scheme
Lectures: 3hrs./week

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

Course Outcomes:

- **Knowledge** of theory and practice related to Industrial IoT Systems.
- Ability to **identify, formulate and solve** engineering problems by using Industrial IoT.
- Ability to **implement** real field problem by gained knowledge of Industrial applications with IoT capability.
- **Analyze** industrial process through data Analytics using Industrial Internet of Things

Course Contents

Unit I Introduction to the Industrial Internet [06 hrs]

What Is the Industrial Internet? Why Industrial Internet and Why Now? Catalysts and precursors of the IIoT. Technical and Business Innovators of the Industrial Internet, IoT Taxonomy, Business Avenues in IIoT, Benefits of IIoT, IoT Ecology, Use cases of IIoT, Purdue Enterprise Reference Architecture (PERA) Model

- Basics of ISA 88 /95 Standards
- Levels of Control Hierarchy

Introduction to Manufacturing, Execution Systems (MES)/Manufacturing Operations Managements Systems (MOMS). Architecture of IIOT, different topologies

Unit II Field Devices (Sensors /Actuators) [08 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, Proximity / Field /PAN Networks**,** Overview of wired and wireless, Topologies of Networks. **Protocols-** Overview of Protocols like ZIGBEE, ZWAVE, MBUS, 6LoWPAN, OPC-UA

Unit III: Middleware Industrial Internet of Things, Platforms [08 hrs]

Middleware Transport Protocols , Software Patterns, Software Design, 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. Software Architecture of Edge/FOG devices. IOT Platform Architecture. Overview & Understanding of COTS cloud platforms like Predix, Thing works, Azure etc.

Unit IV: Data Analytics and Security [08 hrs]

Data analysis techniques, security Basics - Risk, Threat & Vulnerability, Risk Assessment. Security in Manufacturing, PLCs and DCS, securing the OT, Potential Security Issues. Embedded Security.

Unit V: Industry 4.0 [06 hrs]

Defining Industry 4.0, Why Industry 4.0? Main Characteristics of Industry 4.0, Industry 4.0 Design Principles, Building Blocks of Industry 4.0, Industry 4.0 Reference Architecture. Smart Manufacturing / Smart Factories, Industry 4.0 Road Map. IT/OT Convergence and Integration. Digital Transformation

Unit VI: Smart Factories/Case studies [06 hrs]

Introduction, why smart manufacturing? Real world Smart Factories. Case studies.

Text Books

- Industry 4.0: The Industrial Internet of Things 1st ed. Edition by Alasdair Gilchrist
- Internet of Things for Architects -Perry Lea Packt Publishing ISBN 978-1-78847-059-9
- IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things - David Hanes, Gonzalo Salgueiro& others, Cisco Press

Reference Books:

- Industry 4.0 : managing the digital transformation - Cevikcan, Emre, Ustundag, Alp
- The Singapore Smart Industry ReadinessIndex – EDB Singapore

- Sudip Misra, Chandana Roy, Anandarup Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", 1st Edition, Taylor and Francis CRC Press, 2021.
- Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", 1st Edition, A Press E book, 2016.
- E. Balasubramanian, G. R. Kanagachidambaresan, R. Anand, V. Mahima, "Internet of Things for Industry 4.0: Design, Challenges and Solutions", 1st Edition, Springer International Publishing, 2019.

IE (MI)-21008 Imaging Techniques for Medical Applications

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each,
End-Sem Exam - 60

Course Outcomes:

- To understand physics of different Imaging Techniques.
- Acquire knowledge of different image processing techniques with ability to evaluate, analyse and synthesize knowledge related to medical imaging
- Identify, formulate and solve a problem of medical imaging techniques
- Learn and use contemporary tools for solving problems related to medical imaging

Course Contents

Unit I: X-Ray imaging [08hrs]

Introduction to Radiography, Applications of Radiography, Physics of generation of x-rays, x-ray generators, basic interaction between x-rays and matter, Filters, grids, Image acquisition Introduction to Digital Image processing, Image sampling and quantization, Image enhancement

Unit II: Computed Tomography [06 hrs]

Computed Tomography Technique, Applications of CT, CT Generations, Image reconstruction, Artifacts, introduction to Image Processing

Unit III: Nuclear Medical Imaging [08 hrs]

Introduction to nuclear Medical Imaging, single photon emission computer tomography, positron emission tomography, Applications of NMI, Deconvolution, Deblurring, and Restoration, Image coding and data compression, Pattern classification and diagnostic decision

Unit IV: Magnetic Resonance Imaging [08 hrs]

Physics of Magnetic Resonance Imaging, Magnetic Resonance Imaging, Applications of MRI, F-MRI, Image quality and information content, Image enhancement, Analysis of texture, Analysis of oriented patterns,

Unit V: Ultrasonic Imaging [06 hrs]

Introduction of Ultrasonic Imaging, Physics of Ultrasonic imaging, Modes of Ultrasonic Imaging, Applications, Detection of region of interest, Analysis of shapes

Unit VI: Thermography and Optical imaging [06 hrs]

Introduction to Thermography, Thermography Applications; Optical Imaging, Applications; Advanced Imaging Techniques- Fusion Imaging, Electrical Impedance Imaging

Reference books:

- Rangaraj M. Rangayyan, "Biomedical Image Analysis" CRC Press, 2005
- Rafael G. Gonzaleg, Kichard E. Wood, "Digital Image Processing" Pearson Education, LPE
- Bishop, C., "Pattern Recognition and Machine Learning:," Berlin: Springer-Verlag, 2006
- Thomas S. Curry, Jumer E. Dowdey, Robert C. Murry, "Christensen's physics of Diagnostic Radiology", Lippincott Williams & Wilkins, ISBN -10 0812113101
- John G. Webster, "Encyclopedia of Medical Devices and Instrumentation Vol. I , II, III, IV", Wiley Publication
- KavyanNajarian and Robert Splerstor," Biomedical signals and Image processing", CRC – Taylor and Francis, New York, 2006

IOC-Building Management System

Teaching Scheme
Lectures: 2hrs./week

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

Course Outcomes:

- **Understand** basics of Building Automation System.
- **Understand** the basics of HVAC, Access Control and Fire Alarm System
- **Explain** the importance of components & equipment used in these systems.
- **Develop** a simple BAS with integration of protocols and subsystems.

Course Contents

Unit I (7hrs)

Introduction Building Automation Systems, Architecture and Protocols: Introduction to Building Automation systems, different types of subsystems in BAS which includes HVAC, access control, security, fire, lighting systems. Importance of each system in BAS. Process of BAS design, Role of different stakeholders in BAS System design. Different communication protocol and addressing concepts, in open Protocols like BACnet, LON, Profibus, Modbus.

Unit II (7hrs)

HVAC Basic Concepts- (Air Side) and Comfort parameters: Temperature, Heat, Specific Heat, Sensitive Heat & Latent Heat, Enthalpy, Entropy, working principle of different types of relative humidity sensors, Pressure Sensors, air flow sensors, water flow sensors, measurement of CO2 level in air.

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. Design and working of different types of AHU.

Unit III **(7hrs)**

HVAC Basic Concepts- (Plant Side)- Chilled water system & Hot water system: Chilled Water Systems: Concept of refrigeration cycle. Working, mechanical configuration of different types of components used in refrigeration cycle- evaporator, condenser, compressor, expansion valve. Difference between air cooled chiller and water cooled chiller. Working, mechanical configuration of different types of cooling towers. Concept and working of Absorption chiller. Working of different types of chilled water system- single chiller system, series chiller system, parallel chiller system.

Hot water systems: Working of different types of boilers- fire tube, water tube, packaged boiler. Control of boiler- 7 element control, fuel-air ratio control. Working and design of different types of heat exchanger. Sequencing of Boiler Plant

Unit IV **(7hrs)**

Access Control & Fire & Alarm System: Introduction to Access Control system, devices, system architecture. Concept of automation in access control system for safety. Physical security system with components, RFID enabled access control with components.
Introduction to Fire Alarm system, incorporation of comprehensive fire and life/safety systems into a building, Detection system requirement, FAS details standards, Fire suppression methods.

Reference Books

- Albert Ting-pat So, Wai Lok Chan, "Intelligent Building System Enhanced Edition", 1st Edition, Johnson Controls, 2009.
- Roger W. Haines "HVAC Systems Design Handbook", 5th Edition, McGraw-Hill Publication, 2015.
- James E. Brumbaugh "HVAC Fundamentals", Volume 1 to 3, 4th Edition, AUDEL, 2014.
- "Basics of Air Conditioning" ISHRAE, Indian Society of Heating, Refrigerating & Air Conditioning Engineers, 2012.