College of Engineering, Pune

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

Department of Instrumentation & Control
Curriculum Structure & Detailed Syllabus (UG Program)
Final Year B.Tech.

(Revision: A. Y. 2017-18, Effective from: A.Y. 2018-19)

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Program Education Objectives (PEOs):

The Undergraduate students will demonstrate.

I. To provide the students with solid foundation in mathematics, science and Instrumentation Engineering to solve real world problems appropriate to the discipline.

II. To able to apply current industry accepted practices, new and emerging technologies to analyze, design, implement, and maintain state-of-art solutions.

III. To exhibit self-learning capabilities to assimilate and practice emerging theories and technologies. Exhibit teamwork and effective communication skills.

IV. To inculcate professional and ethical attitude and ability to relate automation issues to society at large.

V. To successfully employed or accepted into a graduate program/higher studies, and demonstrate a pursuit of life long learning.

Program Outcomes (POs):

The Undergraduate Students will demonstrate.

a) An ability to apply knowledge of mathematics, Science and Engineering to Instrumentation and Control Discipline

b) Anability to design and conduct experiments for measurement, measurement devices/elements, Control System, variety of control algorithms paradigms, final control elements, etc., and ability to analyze and interpret data.

c) Be able to apply the principles and practices for instrument/system/equipment/device design and development to real world problems adhering to safety and regulatory standards as applicable.

d) Be able to work effectively in a various team (may be multidisciplinary teams).

e) An ability to identify, formulate and solve a problem in Instrumentation and Control Engineering

f) Understand the social impact of automation, safety aspects of automation, hazards associated with various processes, environmental issues, professional ethics,etc.

g) An ability to communicate effectively in oral and written form while formulating project proposals, reports and other related documents.

h) Understand the impact of Instrumentation and Control solutions in a global, economic, environmental, and societal context.

i) Demonstrate the knowledge and capabilities necessary for pursuing a professional career or graduate studies; recognize the need for continuing professional development.

j) Understanding of contemporary and emerging technology for various processes and system

k) Ability to select and use latest hardware and software tools for various processes and systems.

l) Demonstrate an understanding of sensors/transducers, Control system, complete automation system.

m) Demonstrate proficiency in using a high-level/low level programming languages and network protocols for embedded system applications and networked systems.

Correlation between the PEOs and the Pos

PO→ PEO ↓	a	b	c	d	e	f	g	h	i	j	k	l	m
I	✓	✓	✓		✓								
II	✓	✓	✓		✓	✓							
III				✓	✓		✓						
IV								✓	✓	✓	✓	✓	✓
V								✓	✓	✓	✓	✓	✓

Note: The cells filled in with ✓ indicate the fulfilment/correlation of the concerned PEO with the PO.

List of Abbreviations

Abbreviation	Title
S.P. P.U.	Savitribai Phule Pune University
A.Y.	Academic Year
BSC	Basic Science Course
EFC	Engineering Foundation Course
MLC	Mandatory Learning Course
ILOE	Institute Level Open Elective Course
SLC	Self Learning Course
HSMC	Humanities/Social Sciences/Management Course
LLC	Liberal Learning Course
SBC	Skill Based Course
PCC	Program Core Course
DEC	Department Elective Course
LC	Laboratory Course

Semester VII [Scheme-A]

Sr. No	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	ILOE	Institute level Open Elective [Science/Technology/Engg.] Industrial Automation	3	0	0	3
2	LLC	Liberal Learning Course	1	0	0	1
3	DEC	Departmental Elective-I	3	0	0	3
4	PCC	Power Electronics and Drives	3	0	0	3
5	PCC	Process Instrumentation	3	0	0	3
6	PCC	Project Engineering & Management	1	1	2	3
7	LC	Process Instrumentation Laboratory	0	0	2	1
8	LC	Industrial Automation Laboratory	0	1	2	2
9	SBC	Project Stage-I	0	0	4	2
		Total	**14**	**2**	**10**	**21**
		Total Academic Engagement and Credits	**26**			**21**

Elective- I

1. Industrial Internet of Things
2. Flow Engineering
3. Building Automation
4. Medical Instrumentation
5. Digital Control

Minor and Honors Course

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1.		Electronics Instrumentation (Minor)	3	0	0	3
2.		Robust Control (Honors)	3	0	0	3

Semester VII [Scheme-A]

Sr. No	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	PCC	Power Plant Instrumentation	3	0	0	3
2	PCC	Artificial Intelligence and Machine Learning	3	0	0	3
3	MLC	Intellectual Property Rights	1	0	0	0
4	DEC	Department Elective-II	3	0	0	3
5	DEC	Department Elective-III	3	0	0	3
6	SBC	Project Stage-II	0	0	12	6
7	SBC	Seminar	0	0	2	1
		Total	**13**	**0**	**14**	**19**
		Total Academic Engagement and Credits	**27**			**19**

Elective- II and III

1. Batch Process Control
2. Automotive Instrumentation
3. Clinical Engineering
4. Optical Instrumentation
5. Embedded Systems
6. Machine Vision

Minor and Honors Course

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.		Industrial Instrumentation (Minor)	3	0	0	3
2.		Process Dynamics and Control (Honors)	3	0	0	3

Semester VII [Scheme-B]

Sr. No	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	ILOE	Institute level Open Elective [Science/Technology/Engg.] Industrial Automation	3	0	0	3
2	LLC	Liberal Learning Course	1	0	0	1
3	DEC	Departmental Elective-I	3	0	0	3
4	PCC	Power Electronics and Drives	3	0	0	3
5	PCC	Process Instrumentation	3	0	0	3
6	PCC	Project Engineering & Management	1	1	2	3
7	LC	Process Instrumentation Laboratory	0	0	2	1
8	LC	Industrial Automation Laboratory	0	1	2	2
9	SBC	Project Stage-I	0	0	4	2
		Total	**14**	**2**	**10**	**21**
		Total Academic Engagement and Credits	**26**			**21**

Elective- I

1. Industrial Internet of Things
2. Flow Engineering
3. Building Automation
4. Medical Instrumentation
5. Digital Control

Minor and Honors Course

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1.		Electronics Instrumentation (Minor)	3	0	0	3
2.		Robust Control (Honors)	3	0	0	3

Semester VIII [Scheme-B]

Sr. No.	Course Type	Course Name	Teaching Scheme			Credits
			L	T	P	
1	DEC	Open Course- I [MOOC] (From the list of Electives II & III)	3	0	0	3
2	DEC	Open Course- II [MOOC] (From the list of Electives II & III)	3	0	0	3
3	SBC	Project	0	0	24	12
4	SBC	Seminar	0	0	2	1
5	MLC	Intellectual Property Rights	1	0	0	0
		Total	**7**	**0**	**24**	**18**
		Total Academic Engagement and Credits	**33**			**19**

Elective- II and III

1. Batch Process Control
2. Automotive Instrumentation
3. Clinical Engineering
4. Optical Instrumentation
5. Embedded Systems
6. Machine Vision

Minor and Honors Course

Sr. No.	Course Code	Course Name	Teaching Scheme			Credits
			L	T	P	
1.		Industrial Instrumentation (Minor)	3	0	0	3
2.		Process Dynamics and Control (Honors)	3	0	0	3

(*Instrumentation and Control students can opt for this structure if they are planning to go to other institutes of higher learning in India or abroad for a period of six months i.e. only in eight (VIII) semester)

Semester VII

Industrial Automation

Teaching Scheme:
Lectures: 3 Hrs/week

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

Course Outcomes

1. Gained knowledge of Industrial Automation basics [PEO5][PO-i]
2. Selection of control components for given application [PEO2][PO-c]
3. Understanding of contemporary / emerging technology for various applications [PEO2][PO-j]

Unit I **[6 Hrs]**

Fundamentals of Process Controls: 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 **[8 Hrs]**

Transmitters and Converters: Introduction to transmitters, Types, working principle and block schematic, Need for standardization of signals, current, voltage and pneumatic signal standards, concept of live & dead zero,, 2-wire transmitter, HART, Differential Pressure Transmitter: Types, mounting (Installation), manifolds, calibration setup, Application of DPT for level measurement, Zero elevation, Suppression, Calibration of transmitters, I/P converter, P/I converter working principle and calibration procedure.

Unit III **[6 Hrs]**

Control Valves: Necessity and types of valves used in Industries, Construction, Advantages, Disadvantages & applications of Globe: single, double, 3way, angle, Gate, Needle, Diaphragm, Rotary valves, Ball, Butterfly, working principle of pneumatically operated control valve and motorized control valve, Control valve accessories

Unit IV **[6 Hrs]**

Programmable Logic Controller (PLC): Necessity and working principle along with block schematic of PLC, Fixed & Modular PLC (Rack, Slot, Grouping), Specifications, manufacturers, Types of Input & Output modules (AI, DI, AO, DO), wiring diagram, Programming languages, Development of ladder for sequencing of motors, tank level control, ON-OFF temperature control.

Unit V **[8 Hrs]**

Application of PLC in major Industries: working and automation of pump house, Motor Control Centre (MCC), elevator, reactor, and bottle filling using the ladder diagram. Introduction to SCADA and HMI.

Unit VI **[6 Hrs]**

Hierarchical level of automation, Distributed Control System, Plant wide automation, web enabled plants, communication and data transfer issues, wireless technology, advances in process control.

Text Books:

1. Andrew and Williams Gulf "Applied Instrumentation in the process Industries", Volume I, CRC Press, 1980
2. Garry Dunning, "Programmable Logic Controllers" 3rd Ed, PHI Pub. 2004.
   Control Valve Handbook by ISA.

Liberal Learning

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
Continuous Evaluation: 50 Marks
Presentation/demonstration: 50 Marks

Course Outcomes

1. Ability to exhibit self learning capabilities and its use in effective communication [PEO3][POg]
2. An ability to inculcate impact of various areas to relate with society at large [PEO4] [PO-h]

Course Contents

Identification of topic and resources, scope, and synthesize viewpoints for the areas such as performing arts, basic Sciences, business, philosophy, sports and athletics, defense studies and education.

(IE(DE)-18001) Digital Control

Teaching Scheme:
Lectures: 3 Hrs/week

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

Course Outcomes

1. Understanding the basic principles of Microcontroller based design and development [PEO2][PO-m]
2. To encourage the students to have a better understanding on state-of-the-art interfacing technologies, their potential applications and their market views [PEO2][PO-m]

3. Ability to undertake problem identification, formulation and selection of appropriate Microcontrollers [PEO1][PO-e]
4. To test whether students can apply their knowledge of fundamentals of Microcontrollers, programming and interfacing technology to solve and design simple engineering problems [PEO1][PO-a]

Unit-I **[6 Hrs]**

Introduction to Digital control system, Sampling theorem, Effect of sampling, z-transform, Inverse z transform, Zero order hold (ZOH), First order hold (FOH), Frequency domain characteristic of ZOH and FOH

Unit- II **[7 Hrs]**

Shift operator, delta operator Delta Transform, Transfer function in delta domain, w-plane transform, modified z-transform

Unit- III **[7 Hrs]**

Stability analysis, Root locus in z-plane, Magnitude and angle condition, stability relation of continuous and discrete root locus

Unit- IV **[7 Hrs]**

Frequency response in discrete domain, Bode plot, relation of continuous and discrete Bode plot, stability relation, Gain Margin and Phase margin, Bandwidth consideration

Unit- V **[7 Hrs]**

State variable techniques in discrete time, Sate equations of discrete data system with sample and hold, state transition equations, recursive method, z-transform method, Methods of computing state transition matrix

Unit- VI **[6 Hrs]**

Direct Digital design, Descritization design, controller design with pole placement, implementation issues

Reference Books:

1. B.C. Kuo, "Digital Control Systems", 2nd Ed., Oxford publications, 2012.
2. M Gopal, "Digital Control and State Variable Methods", McGraw Hill India; 4th edition, 2012

(IE(DE)-18002) Flow Engineering

Teaching Scheme:
Lectures : 3 Hrs/week

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

Course outcomes

1. Graduates entering the industry will be in a better position to request the data needed for sizing and selecting flow meters and control valves and judge the adequacy and accuracy of the data provided to some extent [PEO5] [PO-a]
2. Graduates entering the industry will be in a better position to select, size flow meters and control valves more or less independently (PEO5)(PO-b)
3. Graduates entering the industry will be in a better position to provide solutions to flow metering and control to some extent (PEO1)(PO-i)

Unit I **[6 Hrs]**

Fluid Properties: Phase Diagram, Density, Viscosity, Compressibility, Gas Mixtures, Wet Gas Isentropic Exponent, Influence Quantities, Process Parameters, Laminar And Turbulent Flow

Unit II **[6 Hrs]**

Flow Measurement Units And Conversions, Flow Calibration Standards, Accuracy And Turndown, Flow Meter Selection, Installation Issues, Pipe Sizing, Flow Straighteners And Conditioners

Unit III **[6 Hrs]**

Installation Methods, Flow Calculation Methods, Uncertainties In Measurement: Orifice Plates, Venturi And Nozzles, Their Geometries, Applications, R.O. Plates, Fixed Geometry Flow Meters, Sizing For Gas And Liquid Application

Unit IV **[7 Hrs]**

Turbine Flow Meters, Vortex Flow Meters, Positive Displacement Flow Meters, Electro Magnetic Flow Meters, Ultrasonic flow Meters, Mass Flow Meter: Coriolis And Thermal Mass Flow Meters, Application For Gas And Liquid Flow Measurement

Unit V **[6 Hrs]**

Introduction to Multiphase Flow Measurement, Critical/Chocked Flow Measurement, Introduction to
CFD

Unit VI: **[9 Hrs]**

Definitions and terminology used for control valves, Sizing for liquid flow, sizing for compressible fluids flow, Flow capacity tests, Cavitation and flashing, incipient cavitation, hydrodynamic noise, Aerodynamic noise Severe service valves

Text Books :

1. R. W. Miller, "Flow Measurement Engineering Handbook", 3rd (third) Edition published by

McGraw-Hill Professional (1996)

2. Roger C. Baker, "Flow Measurement Handbook",Cambridge University Press, September 2009
   Béla G. Lipták, "Process Measurement and Analysis", Volume 1, CRC Press, 2003

Reference Industry Standards :

1. ISO 5167 part 1 to 4 – Measurement of fluid flow by means of pressure differential devices inserted in circular cross section conduits running full
2. IEC 60534 Part 1 to 8 – Industrial process Control Valves
3. ISA – ANSI/ISA 75.01.01 – Flow Equations for Sizing Control Valves

(IE(DE)-18003) Building Automation

Teaching Scheme:
Lectures : 3 Hrs/week

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

Course Outcome:

1. Understand the architecture of BMS system [PEO2] [PO-l]
2. Design and implement HVAC system controls [PEO3] [PO-b]
3. Familiar with protocols and other systems used in BMS [PEO2] [PO-j]

Unit I **[7 Hrs]**

Introduction to intelligent buildings and Building automation systems

Intelligent building, Intelligent architecture and structure, Facilities management vs. intelligent buildings, Lifecycle of building, Evolution of intelligent buildings. BAS System Hierarchy –Field level components, Direct Digital Control (DDC), Supervisory Controller, Server, Operator Workstation (OWS). Different systems in BAS which includes HVAC, security, fire, lighting systems. Importance of each system in BAS. Process of BAS design, Role of different stakeholders (Architect, contractor, consultant, application engineer and engineer) in BAS system design, Comfort parameters for human being- temperature, humidity, flow, pressure, clean air, CO2%.

Unit II **[7 Hrs]**

HVAC Basic Concepts- Systems (Air Side)- Air handling 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. Damper Sizing, Design and working of different types of AHU. Operation of different modes.Concept of Variable Air Volume (VAV) system-Design, working, use of different types of VAV- CAV, Design, working, use of radiation coil, chilled beam, CRAC unit, VRV systems, unit heater, Fan coil unit and unit ventilator.

Unit III **[7 Hrs]**

HVAC Basic Concepts- Systems (Plant Side)- Chilled water system & Hot water system

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

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

Unit IV **[7 Hrs]**

Access Control & BMS Protocols

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

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

Unit V **[7 Hrs]**

Fire &Alarm System

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

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

Unit VI **[7 Hrs]**

Energy Management System and Concept of Green Building

Concept of energy management system, occupancy sensors, fans & lighting controller, Green building concept.

Reference Books:

1. Roger W. Haines “HVAC Systems Design Handbook”, Fifth Edition
2. James E. Brumbaugh “HVAC Fundamentals”, volume 1 to 3
3. “Basics of Air Conditioning” ISHRAE, Indian Society of Heating, Refrigerating & Air Conditioning
   Engineers (product code: B0004 for online shopping)
4. “All About AHU’s”, ISHRAE. Indian Society of Heating, Refrigerating & Air Conditioning Engineers
   (product code: B0005 for online shopping)
5. “Chillers Basics”, ISHRAE. Indian Society of Heating, Refrigerating & Air Conditioning Engineers
   (product code: B0009 for online shopping)

6. "HVAC Handbook Part-1", Indian Society of Heating, Refrigerating & Air Conditioning Engineers
7. "Handbook – Industrial Ventilation Application", 2004 , Indian Society of Heating, Refrigerating
   & Air Conditioning Engineers
8. "Fundamentals Of Refrigeration", Indian Society of Heating, Refrigerating & Air Conditioning
   Engineers
9. "Ventilation Handbook", Indian Society of Heating, Refrigerating & Air Conditioning Engineers

List of experiments:

1. To study IBMS System
2. To study Psychometric chart and various parameters
3. To study various comfort parameters for human being temperature, humidity, flow, pressure, clean air, Co2%.
4. To study different types of Air Handling Units
5. To study various terminal unit systems (CAV, VAV, FCU, UV)
6. To study Chilled Water System and loops
7. To study Hot Water System and loops
8. To study Architecture of BAS system
9. To study building loads and BTU metering

(IE(DE)-18004) Medical Instrumentation

Teaching Scheme:
Lectures : 3 Hrs/week

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

Course Outcomes:

1. Select/ identify appropriate electrode, sensor and transducer for a physiological measurement
   [PEO2] [PO-l]
2. Design different biological signal amplifiers and analysis of bio-signals [PEO2] [PO-c]
3. Identify various blocks of biomedical equipment/ instruments [PEO1] [PO-b]
4. Select biomaterials for an artificial organs/ implants [PEO5] [PO-j]

Unit I **[6 Hrs]**

Introduction to intelligent buildings and Building automation systems

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 **[8 Hrs]**

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 **[8Hrs]**

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 **[7 Hrs]**

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 **[8Hrs]**

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 VI **[8Hrs]**

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

Text Books:

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

Reference Books:

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

(IE -18001) Power Electronics and Drives

Teaching Scheme:
Lectures: 3 hrs/week

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

Course Outcomes

1. Ability to analyze various power devices and their specification parameters [PEO2][PO-b]
2. Ability to select various converters for a specific application [PEO2] [PO-c]
3. Ability to select, design various DC and AC drives [PEO4] [PO-e]

Unit I **[6 Hrs]**

Power devices

Classification of Electric Drives, Requirements of Electric Drives, Working, Characteristics, specifications and applications of diode, BJT, SCR,TRIAC, DIAC, Power MOSFET,IGBT and UJT. SCR gate triggering and commutation circuits. Series and Parallel connection of SCR and its triggering arrangement.

Unit II **[7 Hrs]**

Converters, inverter and chopper

Single Phase and Three Phase Controlled rectifiers, (Half wave, full wave and bridge Configuration) with R and R-L. Single Phase uncontrolled rectifiers.
Dc-dc converters: buck, boost, inverting buck-boost and noninverting buck-boost dc-dc converters.

Unit III **[6 Hrs]**

Inverters and PWM techniques

Voltage source inverters, Current source inverters , PWM techniques - sine-triangle comparison , harmonic elimination, hysteresis current controllers, space vector PWM

Unit IV **[7 Hrs]**

DC motor drives

Introduction to dc motors, modelling of dc motors, speed-torque characteristics DC shunt, PMDC and series motors, Speed and position control methods, H-Bridge Drive.

Unit V **[7 Hrs]**

AC motor drives

Solid state relays, Firing angle control, Closed loop control of induction motor, Speed and direction control, ACSynchronous motor drive, Closed loop control of synchronous motor, Variable frequency drive.

Unit VI **[6 Hrs]**

Special motor drives

Introduction to stepper motor, important feature of stepper motor, stepper motor sequencer and drive, Half step and Full step method of stepper motor drive, torque vs stepping rate characteristics. Introduction to brushless dc motor (BLDC), BLDC motor drive. Introduction of dc servo control.

Reference books:

1. Mohamad Rashid, "Power Electronics", PHI, 2nd edition, 2004
2. P. C. Sen," Power Electronics", TMH, 2007
3. G.K.Dubey," Power semiconductor controlled drives", Prentice Hall- 1989
4. G. K. Dubey," Fundamentals of Electrical Drives", CRC Press, 2002
5. Krishnan, "Electrical Motor Drives", PHI-2003

(IE -18002) Process Instrumentation

Teaching Scheme:

Lectures: 3 Hrs/week

Examination Scheme:

T1 and T2: 20 Marks each

End-Sem Exam: 60 Marks

Course Outcomes:

1. Ability to analyze the process loops and identify the characteristics [PEO2][PO-c]
2. Ability to apply various control techniques to Processes [PEO1] [PO-a]
3. Ability to design multivariable scheme [PEO5] [PO-i]

Unit-I **[7 Hrs]**

Process Characteristics

Types of processes (dead time, single & multi capacity, self & non-self-regulating, interacting & non- interacting, Linear & non-linear), Process gain, process reaction curve,

process time constant & constant step analysis method for finding time constant, dead time, dynamic elements in control loops, PID control of processes, Process simulator.

Unit- II **[7 Hrs]**

Loop Component Design

Valve sizing as per standard ANSI/ISA-S-75.01, Valve capacity & testing by ANSI/ISA-S-75.02, Orifice plate design as per ISO 5167standard, Field instruments installation practices, selection of part number for field instruments.

Unit- III **[7 Hrs]**

Analysis of some common loops

Analysis of Flow control, pressure control, level control, temperature control, pH control, Composition control etc., Statistical Process Controls.

Unit- IV **[7 Hrs]**

Multi Loop & Multivariable process control systems

Feedback, Feed Forward control, Cascade Control, Ratio Control, Selective Control, Split-range Control. Interaction and its effect, Decoupling methods, Relative Process Gain Matrices (RPG) & applications, Stability of multiloop control system, SLPC and MLPC comparison.

Unit- V **[7 Hrs]**

Control system of various process plants

Process flow diagram, Design aspects and selection criterion for field instruments and develop instrumentation scheme for Boiler, Heat Exchanger, Evaporator, Distillation Column, Spray Dryer, Control schemes of the plants.

Unit- VI **[7 Hrs]**

Intelligent and advanced Control

Expert systems & expert controllers (AI based),Fuzzy Controllers, Artificial Neural networks & ANN Controller, Neuro-Fuzzy Control System, Neuro-MPC, Model Based controllers (self-tuning & Model reference Adaptive Controller), Optimal Controller using Kaman filter, Model Predictive Controller.

Text Books:

1. Bela G Liptak, “Instrument Engineers Handbook: Process Control”, Chilton, Third ed., 1995
2. F. G. Shinskey, “Feedback controllers: Tuning, Applications & Design”, McGraw-Hill, 4th ed.
3. Krishna Kant,”Computer based Industrial control , Prentice Hall of India, First ed., 2009
4. F. G. Shinskey,”Process Control Systems”, McGraw-Hill, 1996.

Reference Books:

1. William Andrews, “Applied Instrumentation in process industries “, Gulf, Second ed., 1979
   Control Valve Handbook, Fisher Control International Inc., Third ed.,2001

2. G. Stephanopolous, " Chemical Process Control", Prentice Hall of India, 1984
   Distillation column control ISA Publication
3. ISA Handbook of Control Valves
4. Douglas M. Considine, "Process Instrumentation and control Handbook", McGraw-Hill, 1984

(IE-18003) Project Engineering & Management

Teaching Scheme:
Lectures : 1hr/week
Tutorial: 1 hr /week
Practical: 2 hrs/week

Examination Scheme:
T1 and T2: 10 Marks each
End-Sem Exam: 30 Marks
Practical & Viva: 50 Marks

Course Outcomes:

1. Understand the basics of project management [PEO1] [PO-a]
2. Understand functional stages of project planning designing and budgetting [PEO2] [PO-c]
3. Understand estimation and risk management [PEO2] [PO-c]

Unit I **[5 Hrs]**

Introduction to Project Management

Definition of project purpose - Scope, time, quality and organization structure.Methods/ process of tendering, Types of projects and types of contracts. Project team, Roles and responsibilities of parties, Role of project manager, Project scope definition, Early estimates and project budget, Risk analysis.

Unit II **[4 Hrs]**

Project Management Functions

Project planning and scheduling, work plan development, management cycle phases, projects specifications, bar charts, milestones, schedules, work breakdown structures, cost breakdown structures

Unit III **[5 Hrs]**

Project Tracking and Estimation

Program evaluation and review techniques (PERT) and critical path method (CPM), estimating activity time and total program time, total PERT/CPM planning crash times, software's used in project Management, Personal Management Skills. Risk Management.

Text Books:

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

Reference Books:

1. Bela G Liptak, "Instrument Engineers Handbook: Process Control", Chilton, 3rded., 1995.

(IE-18004) Process Instrumentation Laboratory

Teaching Scheme:
Lectures:2 Hrs/week

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

Course Outcomes:

1. 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-b]
2. An ability to identify, control loop in a given process and apply appropriate control strategy
   [PEO1][PO-e]
3. An ability to select and use latest hard ware and software tools for various processes and systems [PEO2][PO-k]

List of experiments:

1. Study & analysis of Process flow diagram, design aspects for Boiler, Heat Exchanger, Evaporator, Distillation Column, Spray Dryer.
2. Selection of field instruments for Boiler, Heat Exchanger, Evaporator, Distillation Column, Spray
   Dryer.
3. Designing of control valve for liquid/gas/vapour applications as per standard
4. Design of orifice plates for liquid/gas/vapouras per ISO 5167
5. Design of pneumatic or electric actuator
6. Development of control loops for Boiler, Heat Exchanger, Evaporator, Distillation Column, Spray Dryer.
7. Study & analysis of flow, pressure, and level control loop (Analysis includes process parameters such as type of process, dead time, capacityetc.)
8. Configuration of PID controller for specific loop
9. Design and Implementation of cascade controller for a given application.
10. Design & implementation of feed-forward controller for a given application.

(IE-18005) Industrial Automation Laboratory

Teaching Scheme:
Lectures :2 Hrs/week

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

Course Outcomes:

1. Understanding of different architectures and blocks in DCS [PEO1] [PO-c]
2. Designing and implementing a DCS based control for a plant [PEO2] [PO-b]
3. Understanding DCS as tools [PEO4] [PO-j]

List of Experiments:

1. Study of various architectures of Distributed Control System.
2. Study of various modules installed/commissioned in DCS.
3. Start-up procedure for DCS and software aspects for the implementation.
4. Configuration and commissioning of Digital I/O's for a typical system.
5. Configuration and commissioning of Analog I/O's for a typical system.
6. Configuration and commissioning of control block for a typical system.
7. Configuration and commissioning of logical, timer, counter modules for a typical system.
8. Configuration and implementation of field bus components.
9. Design and deploy communication with external devices /systems using modbus.
10. Development of GUI for a typical plant.
11. Development of an alarm, and historian system for a typical process.
12. Implementation of the logic, GUI, and trends for a typical plant.

(IE-18006) Project Stage-I

Teaching Scheme:
Lectures :2 Hrs/week

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

Course Outcomes:

1. Ability to work effectively in a various team (may be multidisciplinary teams) [PEO3] [PO-d]
2. Identify, formulate and solve a problem of Instrumentation and Control Engineering [PEO1] [PO-e]
3. Understand the impact of Instrumentation and Control solutions in a global, economic , environmental and societal context [PEO4] [PO-h]

Course Contents:

To familiarize the students about the standards and practices used in industry/ research organization/In- house research. The study leads towards finalization of the problem statement for project work, which is helpful to establish a link between industry and academia for low cost solution, identification of current need of the society as well as industrial research.

(IE(HO)-18001) Robust Control

Teaching Scheme:
Lectures : 3 Hrs/week

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

Course Outcomes:

1. Ability to design robust controllers [PEO1,PO-a,e]
2. Ability to design different advance controllers to achieve desired performances [PEO1,PO-a,b,e]
3. Ability to design different controllers in discrete domain using delta operator [PEO1,PO-a,b]

Unit-I **[7 Hrs]**

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 **[6 Hrs]**

Sliding mode control, chatter control, Simple Sliding mode control design, Sliding mode control for linear system

Unit- III **[7 Hrs]**

Sliding mode control based on reaching law, Robust Sliding mode control based on reaching law, Quasi sliding, Reaching phase elimination

Unit- IV **[8 Hrs]**

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 **[6 Hrs]**

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- VI **[6 Hrs]**

State observers, Simultaneous state and uncertainty observers, Extended state observer, disturbance observers, Some case studies, Adaptive sliding mode control

Reference Books:

1. C. Edwards and S.K. Spurgeon, “Sliding Mode Control: Theory and Applications”, Taylor & Francis, 1998.

2. G. Bartolini, L.Fridman, A. Pisano and E. Usai (Ed.), "Modern sliding mode control theory", Springer, 2008. 3. J.J.E Slotine and W. Li, "Applied nonlinear control", Prentice Hall, 1991.

(IE(MI)-18001) Electronic Instrumentation

Teaching Scheme:
Lectures : 3 Hrs/week

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

Course Outcomes:

1. Select/ identify appropriate electronic instrument for a typical application [PO-c, PEO1]
2. Identify various blocks of electronic instruments for measurement and testing [PO-b, PEO3]
3. Select appropriate data transmission technique for effective communication [PO-c, PEO1]

Unit-I **[6 Hrs]**

Digital Instruments

Digital frequency meter, Universal counter and their applications like event, ratio, totalizing and timers etc. significance of digit, Automation in digital instruments.

Unit- II **[7 Hrs]**

Signal Sources

Sine wave generator, sine wave synthesis, audio and function generator, RF signal generator, arbitrary waveform generator and its applications in instrumentation

Unit- III **[7 Hrs]**

Signal Analysers

Introduction to total harmonic distortion, wave analyser and its applications, FFT analyser and Network analyser and their applications

Unit- IV **[8 Hrs]**

Virtual instrumentation

Applications of virtual instrumentation, typical case study, environment, front panel, block diagram, data flow

Unit- V **[6 Hrs]**

Measuring Instruments and Test Equipment

RMS definition, RMS measurement, RMS value of sine and pulse, True RMS, True RMS meter, DMM, Standard AC and DC sources

Unit- VI **[6 Hrs]**

Data Transmission Techniques

Introduction to data transmission techniques, Pulse modulation, digital modulation techniques like Amplitude Shift Keying, Phase shift Keying, telemetry and its applications in Instrumentation.

Test Books:

1. David Bell; "Electronic Measurement and Instrumentation" Prentice Hall 2nd ed. 2000.
2. A.J. Bowens; "Digital Instrumentation" McGraw-Hill, 1st ed. 1986
3. C.S. Rangan, G.R. Sarma, V.S.V. Mani; "Instrumentation Devices and Systems "Tata McGraw Hill 2nd ed. 1997.

Reference Books:

1. J.J.Carr; "Elements of Electronic Instrumentation and Control" Prentice Hall 3rd ed. 2009.
2. W.Cooper, A.Helfric; "Electronic Instrumentation and Measurement Techniques "PHI 3rd ed. 2005.
3. Coombs; "Handbook of Electronic Instrumentation", Mc Graw Hill, 1972

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Semester VIII

(IE-18007) Power Plant Instrumentation

Teaching Scheme:
Lectures : 3 Hrs/week

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

Course Outcomes:

1. Gain knowledge of Instrumentation used in power plant [PEO1][PO-c]
2. Demonstrate the standards/knowledge necessary for pursuing a professional career [PEO5][POi]
3. Understand the impact of Instrumentation and Control solution to power industry in environmental and societal context [PEO4][PO-h]

Unit I **[7 Hrs]**

Boiler Ancillaries

Concepts and terminology of measurement system, transducer, sensor, range and span, classification of transducers, static and dynamic characteristics, selection criteria, sources of errors and their statistical analysis, standards and calibration.

Unit II **[7 Hrs]**

Boiler Control

Types of boilers, various control such 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, sequence event recorder, supervisor control, data acquisition controls, burner management systems and controllers. Start-up and shut-down procedures, Boiler safety standard, Boiler inspection procedures. Boiler load calculation, boiler efficiency calculation

Unit III **[7 Hrs]**

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 **[7 Hrs]**

Nuclear Power Plant Instrumentation

Classification Of Nuclear Reactors, Nuclear Reactor Control Loops, Fuel Cycle, Pressure Sensing-Line Dynamics, On-Line Detection Of Sensing Line Problems

Unit V **[7 Hrs]**

Non-Conventional Energy System

Solar: 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 **[7 Hrs]**

Smart Grid Infrastructure

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

Text Books:

1. Sam. G. Dukelow, "The Control of Boilers", 2nd Edition, ISA Press, New York, 1991
2. Manoj Kumar Gupta, "Power Plant Engineering", PHI Learning Private Limited, 2012
3. G.S. Sawhney, "Non-Conventional Energy Resources", PHI Learning Private Limited, 2012
4. H. M. Hashemian, "Maintenance of Process Instrumentation in Nuclear Power Plants", Springer, 2006

Reference Books:

1. David Lindsley, "Boiler Control Systems", McGraw Hill, New York, 1991.
2. Modern Power Station Practice, Vol.6, "Instrumentation, Controls and Testing", Pergamon Press, Oxford, 1971.

During term industrial visits will be arranged to two power stations. Purpose of visit is to study technology used in power stations. This is compulsory activity to all students.

(IE-18008) Artificial Intelligence and Machine Learning

Teaching Scheme:
Lectures : 3 Hrs/week

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

Course Outcomes:

1. Understand Artificial Intelligence and its approaches [PEO1] [PO-a]
2. Solving some problems using Artificial Intelligence [PEO4] [PO-m]
3. Understand Supervised, unsupervised and semi supervised machine learning algorithm [PEO1] [PO-b]

4. Study of probabilistic analysis, parametric and non-parametric algorithms [PEO2] [PO-e]
5. Estimation of Maximum Likelihood, losses and risks for sample implementation, clustering algorithms [PEO2] [PO-c]

Unit I **[7 Hrs]**

Artificial Intelligence - Introduction, Intelligent Agents, Problem-solving, Solving Problems by Searching, Informed Search and Exploration, Constraint Satisfaction Problems, Adversarial Search, Knowledge and reasoning, Logical Agents, First-Order Logic, Inference in First-Order Logic, Knowledge Representation

Unit II **[6 Hrs]**

Planning, Planning and Acting in the Real World, Uncertain knowledge and reasoning,Uncertainty, Probabilistic Reasoning, Probabilistic Reasoning over Time, Making Simple Decisions, Making Complex Decisions

Unit III **[7 Hrs]**

Introduction to Machine Learning: What is machine learning, Applications of ML,Design Perspective and Issues in ML, Supervised, Unsupervised, Semi-supervisedlearning with applications and issues, Input : Concepts, instances and attributes, Output: Knowledge Representation: Decision tables, Decision trees, Decision rules, Rules involving relations, Instance-based representation, Data Pre-processing-data cleaning, data integration and transformation, data reduction, data discretization and concept hierarchy generation.

Unit IV **[8 Hrs]**

Introduction to Classification, issues regarding classification, Classification : Model(or hypothesis) representation, decision boundary, cost function, gradient descent,regularization.Diagnostic: debugging a learning algorithm, evaluating a hypothesis(Modelselection), training/validating/testing procedures, diagnosing bias versus varianceand vice versa, regularization and bias/variance, learning curves.Accuracy and Error measures: classifier accuracy measures, predictor errormeasure, evaluating the accuracy of a classifier or predictor, Confusion metric,precision, recall, tradeoff between both, accuracy.

Unit V **[8 Hrs]**

Decision Tree : representation, hypothesis, issues in Decision Tree Learning,Pruning, Rule extraction from Tree, Learning rules from Data, Probabilistic classifier: Bayes rule, Maximum Likelihood Estimation, case Study, Clustering :Unsupervised learning technique, Similarity and Distance Measures, k-means and k-medoids algorithm, optimization objective, random initialization, choosing value of k, EM algorithm

Unit VI **[6 Hrs]**

Framework for machine learning applications, human-computer interaction, Case studies in the domain of Measurement, Analysis and Control, etc.

Text Books:

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

Reference Books:

1. K.P. Soman, R. Longonathan and V. Vijay, "Machine Learning with SVM and Other Kernel Methods", PHI-2009
2. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer 2006.
3. Tom M. Mitchell , "Machine Learning", McGraw-Hill, 1997
4. The Elements of Statistical Learning - by T. Hastie, R. Tibshirani, and J. Friedman, 2009

Intellectual Property Rights

Teaching Scheme:
Lectures:1 hr/week

Examination Scheme:
Test-I-0 Marks, Test-II-0 Marks
End-Sem Exam- 50 Marks

Course Outcomes:

1. Understood the importance of IPR [PEO4][PO-h]
2. Understood how IPR are regarded as a source of national wealth and mark of an economic leadership in the context of global market scenario [PEO4][PO-h]

Unit I: Introduction **[2 Hrs]**

Nature of Intellectual Property, Patents, Designs, Trademarks and Copyrights, Process of patenting and
Development-technological research, Innovation, patenting, development.

Unit II: International Scenario **[2 Hrs]**

International cooperation on Intellectual Property, Procedure for grants of patents, patenting under PCT.

Unit III: Patent Rights **[3 Hrs]**

Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.

Unit IV: New developments in IPR **[3 Hrs]**

Administration of Patent system, New developments in IPR, IPR Biological systems, Computers, Software etc., Traditional knowledge, Case studies, IPR and IIT's objectives towards learning IPR.

Unit V: Trademark and patenting **[3 Hrs]**

Registered and unregistered trademarks, designs, concepts, idea patenting.

Text Books:

1. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd., 2nd ed. 2007.

Reference Books:

1. Robert P. Merges, Peter S. Meneil, Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 4th ed., 2007.

(IE(DE)-18005) Batch Process Control

Teaching Scheme:
Practical: 3hrs/week

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

Course Outcomes:

1. Acquired knowledge of standards used for Batch process control [PEO1][PO-c]
2. Development of control schemes for different batch process P&IDs [PEO5][PO-i]

Unit I: Introduction **[7 Hrs]**

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

Unit II: S88 Standard **[8 Hrs]**

Discontinuous: ON/OFF Continuous: Proportional, integral, derivative, proportional-Integral, Proportional- Derivative, Proportional-Derivative-Integral, Anti-reset windup, Rate before reset Concept of bump less transfers in PID controller, Effect of process Characteristics on PID combination, control actions for various processes.

Unit III: Control of batch Process **[6 Hrs]**

General control requirements, safety interlocking, regulatory & discrete controls, sequential control of batch processes, control activities and process management, information handling for a batch process.

Unit IV: Design of batch control systems **[6 Hrs]**

Batch management, recipe management, and production scheduling & information management. Batch control system design, system requirements, system hardware/reliability requirement.

Unit V: Specifications and data management **[6 Hrs]**

Batch control system specifications and implementation, Information/display requirements, cost justification and benefits, data management.

Unit VI: Implementation & case studies **[7 Hrs]**

Generic implementation of batch processes, case study of batch control system implementation for applications in food and beverages, pharmaceuticals etc.

Text Books:

1. Thomas .G. Fisher William M. Hawkins, "Batch Control Systems", ISA series, 1st ed., 2008
2. Thomas .G. Fisher William M. Hawkins, "Batch Control Systems", ISA series, 2nd ed., 2012.

(IE(DE)-18006) Automotive Instrumentation

Teaching Scheme:

Lectures: 3 Hrs / week

Examination Scheme:

T1 and T2: 20 marks each

End-Sem Exam: 60 marks

Course Outcomes:

1. Various aspects of automotive electronics, automotive subsystems and components. [PEO 1][PO-c]
2. Basic principle of automotive sensors and body electronics. [PEO 2][PO-c]
3. Engine management system and automotive systems control algorithms. [PEO 3][PO-i]
4. Basic principle, architecture and working of electric vehicles. [PEO 4][PO-b]
5. Automotive communication standards and coding standards like MISRA C. [PEO 4][PO-m]

Unit I **[5 Hrs]**

Current trends in automobiles with emphasis on increasing role of electronics and software. Overview of generic automotive control ECU functioning. Overview of typical automotive subsystems and components.

Unit II **[6 Hrs]**

Engine Management Systems: Basic sensor arrangement, types of sensors such as oxygen sensors, crank angle position sensors, Fuel metering/ vehicle speed sensors, Flow sensor, temperature, air mass flow sensors, Throttle position sensor, solenoids etc. Algorithms for engine control including open loop and closed loop control system, electronic ignition, EGR for exhaust emission control.

Unit III **[6 Hrs]**

Vehicle Power Train and Motion Control: Electronic Transmission Control, Adaptive Power Steering, Adaptive cruise control Safety and comfort systems Anti-lock braking, Traction Control and Electronic Stability, Active suspension control.

Unit IV **[7 Hrs]**

Body Electronics: lighting control, remote keyless entry, immobilizers etc. Electronic instrument clusters and dashboard electronics. Aspects of hardware design for automotive including electro-magnetic interference suppression, Electromagnetic Compatibility etc.

Unit V **[8 Hrs]**

Electric Vehicle: Introduction, reasons for EV development, advantages and disadvantages, challenges, basic concepts of electric traction and architecture of an electric car, electric power generation, energy storage, conversion to mechanical power, power train, drive train and electric drives. Hardware in loop testing of automotive ECU using available software/hardware platform Simulation.

Unit VI **[8 Hrs]**

Automotive Standards and Protocols: Automotive standards like CAN protocol, LIN Protocol, Flex Ray, OBD-II etc. Automotive Coding standards like MISRA, introduction to autonomous vehicle.

Text Books:

1. William B. Ribbens, "Understanding Automotive Electronics", 6th Edition, 2003, Newnes (Imprint of Elsevier Science).
2. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley, 2003

Reference Books:

1. Young A.P. & Griffiths, " Automotive Electrical Equipment" , ELBS & New Press-1999
2. Tom Weather Jr. &Cland c. Ilunter, "Automotive computers and control system" Prentice Hall
   Inc., New Jersey
3. Crouse W.H., "Automobile Electrical Equipment" ,McGraw Hill Co. Inc., New York, 1995.
4. Bechhold, " Understanding Automotive Electronic", SAE,1998.
5. Robert Boshe" Automotive Hand Book" (5th edition),2000.

(IE(DE)-18007) Clinical Engineering

Teaching Scheme:
Lectures: 3 Hrs / week

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

Course Outcomes:

1. To define terms used in respiratory, pathology and radiology measurements [PEO1] [PO-a]
2. To design and realisation of various blocks of medical instruments/ equipment [PEO2] [PO-b]
3. Apply electrical safety aspects and standards in medical instruments/ equipment [PEO4] [PO- f]
4. Apply knowledge of mathematics, science and materials to orthotics and prosthetic devices[PEO1] [PO-a]

Unit I **[6 Hrs]**

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 **[6 Hrs]**

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 **[8 Hrs]**

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 **[6 Hrs]**

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 **[8 Hrs]**

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 VI **[8 Hrs]**

Imaging systems

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

Text Books:

1. Carr and Brown, Englewood Cliffs, "Introduction to biomedical equipment technology", N.J.REGENTS/Prentice Hall, 2nd ed., 1993.
2. John G. Webster, "Medical instrumentation application and design", John Wiley & Sons Pvt. Ltd,4th ed., 2009.

Reference Book:

1. Jacobsons and Webster, "Medicine and clinical engineering", PHI illustrated ed. 1977.
   Dr. John G Webster, "Encyclopaedia of medical devices and instruments", Wiley Publication, 1988.
2. M. Arumugam, "Biomedical instrumentation", Anuradha publishers,4th ed., 1992.
3. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, "Biomedical instrumentation Pearson
   Education", 2nd ed., 1980.
4. R. S. Khandpur, "Handbook of biomedical instrumentation", TMH, 2nd ed., 2008.
   Richard Aston, "Principles of biomedical instrumentation and measurement", Maxwell
   Macmillan, International ed., 1990.

(IE(DE)-18008) Optical Instrumentation

Teaching Scheme:

Lectures: 3 Hrs / week

Examination Scheme:

T1 and T2: 20 marks each

End-Sem Exam: 60 marks

Course Outcomes:

1. Apply LASER and Optical fiber for various physical parameter measurements [PEO 2][PO-c]
2. Analyzing the optical sensor technology on various parameters of measurements [PEO 2][PO-l]

Unit I **[6 Hrs]**

Optical fiber waveguide

Ray theory of transmission, total internal reflection, and electromagnetic mode theory of optical propagation, cylindrical fiber, classification of fibers, manufacturing of optical fiber.

Unit II **[7 Hrs]**

Transmission characteristics of optical fiber

Attenuation, material absorption losses, scattering losses, nonlinear and linear scattering, fiber bend loss, dispersion, intermodal dispersion, dispersion modified single mode fiber, dispersion flattened fibers, polarization, nonlinear phenomena.

Unit III **[8 Hrs]**

Optical sources and detectors

Optical emission from semiconductor, semiconductor LASER, non semiconductor LASER, LED as an optical source, optical detector principles, absorption, quantum efficiency, responsively, photo diodes, modulation.

Unit IV **[8 Hrs]**

Optical fiber sensors

Introduction to fiber optics sensors, sensors based on intensity modulation, application of optical fiber for displacement, strain, stress and pressure measurement. Active multimode FO sensors, micro-bend optical fiber sensors, current sensors, phase modulated, polarization modulated optical fiber sensors, fiber optic gyroscope.

Unit V **[7 Hrs]**

LASER applications

Introduction, application of LASER in biomedical instrumentation, LASER interferometry, performance parameters, LASER telemeters, measurement of distance, LIDAR, holography: basic principle of holography, measurement of strain, stress, bending moments and vibrations using hologram.

Unit VI **[6 Hrs]**

Optical amplification and integrated optics

Optical amplifiers, integrated optics integrated optical devices: beam splitters, directional couplers, modulators, switches, optoelectronics integration and differentiation, analog arithmetic operations, digital optics.

Text Books:

1. Jose Miguel Lopez, “Optical fiber sensing technology”, John Wiley & Sons, 2002
2. AjoyGhatak, “Optics”, Tata Mc- Graw Hill Publishing, 5th ed., 2012

Reference Books:

1. Joseph T Verdeyen, “LASER Electronics”, Prentice Hall of India, 3rd ed., 2003

2. John M. Senior, “Optical fiber Communications Principles and Practice”, PHI publication, 2nd ed.,2008

(IE (DE)-18009) Industrial Internet of Things (IIoT)

Teaching Scheme:
Lectures: 3 Hrs / week

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

Course Outcomes:

1. Understanding of IIoT is? [PEO2] [PO-j]
2. Knowledge of Key components of IIoT, Architectures and its pros & cons [PEO1] [PO-c]
3. Understanding of different IIoT Business Models [PEO2] [PO-e]
4. Basic understanding of various Industrial IoT platforms [PEO3] [PO-j]

Unit I **[8 Hrs]**

Introduction to IIoT & IIoT Architectures

Introduction: What is IIoT?, Definition of IoT,Overview of Components of IIoT – Sensors, Networks, People & Processes, Definition of IIoT, Differentiation between IoT&IIoT, Differentiation between IIoT& OT, Why need 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 IoTIoTTaxonomy, Business Avenues in IIoT, Benefits of IIoT, IoT Ecology, Usecases of IIoT

IoT Architectures: 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 II **[6 Hrs]**

Components of IIoT – Field Devices (Sensors /Actuators) & Field Networks /PAN Networks

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 Network**: Overview of wired and wireless, Topologies of Networks **Protocols:** Overview of Protocols like ZIGBEE, ZWAVE, MBUS, 6LoWPAN, OPC-UA

Unit III **[8 Hrs]**

Components of IIoT – Plant Network &IoT Protocols, Edge Devices, FOG Devices

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 IV **[8 Hrs]**

IIoT Platform Architecture & COTs Platforms, Business Models

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

Unit V **[6 Hrs]**

IoT Privacy, Security & Governance

Security Basics - Risk, Threat & Vulnerability, Risk Assessment, IIoT Security Framework based on IIC, Basic understanding of various IIoT security standards like NIST 82, IEC 62443, NERC, NIC etc., Hardware based Security

Unit VI **[4 Hrs]**

Overview of Data analytics, Cloud services, IIoT Use cases& Recent Trends in IOT

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

Reference Books:

1. Industrial Internet Vocabulary - IIC
2. The Industrial Internet of Things Volume G1: Reference Architecture – IIC
3. Industrial Internet of Things Volume G4: Security Framework – IIC
4. The Industrial Internet of Things, Volume B01: Business Strategy and Innovation Framework – IIC
5. Industrial Analytics: The Engine Driving the IIoT Revolution
6. Karen Rose, Scott Eldridge, Lyman Chapin, “The Internet of Things: An Overview Understanding the Issues and Challenges of a More Connected World” Internet Society
7. Bahga – Madisetti, “Internet of things Book – A hands on Approach”
8. Olivier Hersent, “The Internet of Things: Key Applications and Protocols”, 2nd Edition
9. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, 1st ed. Edition
10. Industrial Automation and Control System Security Principles: Protecting the Critical
11. Ronald L. Krutz, PhD, PE, “Infrastructure”, Second Edition

(IE (DE)-18010) Embedded Systems

Teaching Scheme:

Practicals: 3 Hrs / week

Examination Scheme:

T1 and T2: 20 marks each

End-Sem Exam: 60 marks

Course Outcomes:

1. Understanding of RISC architecture of processor, its features and applications [PEO 1][PO-c]
2. Hands on usage of IDE of processors and algorithm development [PEO 2][PO-b]

3. To understand concept of OS, RTOS and application perspectives [PEO 4][PO-i]
4. Study, design, analyze and prototype various embedded systems [PEO 3][PO-m]

Unit I **[6 Hrs]**

ARM-Cortex M series architecture

Embedded systems, classification, ARM 32-bit microcontroller Tiva, architecture—technology overview, Architectural Features of ARM Cortex M series: Tiva Block Diagram, CPU modes, register organization, ROM, RAM, timers, data and address bus, Memory and I/O interfacing concepts, memory mapped I/O. CISC Vs RISC design philosophy, Von-Neumann Vs Harvard architecture, instruction set, pipelining, exceptions and its handling, memory, I/O's and addressing modes.

Unit II **[6 Hrs]**

Operating system based development

Operating systems fundamentals, operating system services, memory management, process management, device management, file management, Operating system services-program execution, I/O operation, file manipulation, communication, Operating system properties- multitasking, parallel programming, interactivity, scheduling and scheduling algorithms.

Linux: An overview of Red Hat Linux, installing Ubuntu, Linux commands, shell scrip programming, embedded Linux.

Unit III **[6 Hrs]**

Development Tools (Open Source)

GNU tools, text editors-vi, nano, pico,etc. IDE-Eclipse, code lite, compilers-gcc, g++, debuggers, cross- compilers, gcc- arm specific tool chains and in line assembly, Writing and compiling C/C++ programs, cross-compilation for ARM development board, Basics of make file, static and dynamic libraries.

Unit IV **[8 Hrs]**

Kernel programming

Kernel, basic functionalities of kernel, kernel module programming, Linux kernel sources, kernel configuration, booting kernel, kernel booting parameters, root file system,bootloader,U- boot,portingLinuxonARMboard,devicedriverprogramming, architecture, I/O communication, writing simple character device driver.

Unit V **[8 Hrs]**

RTOS

RTOS concepts using Tiva : foreground and background systems, critical section, shared resources, tasks, multitasking, context switching, kernels, pre-emptive and non-pre-emptive schedulers, static and dynamic priorities, priority inversion, mutual exclusion, synchronization, inter task communication mechanisms, Interrupts: latency, response and recovery, clock tick, memory requirements.

Unit VI **[8 Hrs]**

Interfacing and application development

Interfacing of peripherals using Tiva: LED and sensors, ADC, Timer, PWM, UART, SPI, I2C.Development of web server, wireless module interfacing, camera interfacing, open CV on Beagle Bone Black. Control application, Java programming on Beagle Bone Black, porting android for mobile applications like controlling Beagle Bone Black I/O through mobile.

Text Books:

1. Sloss Andrew N, SymesDominic, Wright Chris, "ARM System Developer's Guide: Designing and Optimizing", Morgan Kaufman Publication, 2004.
2. MichaelBeck,"Linuxkernelprogramming",Addison-WesleyProfessional,3rd ed. 2002.
3. Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers, 2014, Jonathan W Valvano Create space publications ISBN: 978-1463590154.
4. Embedded Systems: Introduction to ARM Cortex - M Microcontrollers, 5th edition Jonathan W Valvano, Create space publications ISBN-13: 978-1477508992

Reference Books:

1. Raj Kamal,"Embedded Systems – Architecture: Programming and Design",Tata McGraw-Hill Education, 3rd ed.,2003.

(IE(DE)-18011) Machine Vision

Teaching Scheme:

Practicals: 3 Hrs / week

Examination Scheme:

T1 and T2: 20 Marks each

End-Sem Exam: 60 marks

Course Outcomes:

1. Apply knowledge of mathematics for image understanding and analysis [PEO 1][PO-a]
2. Design and analysis of techniques / processes for image understanding [PEO 2][PO- b]
3. To design, realize and troubleshoot various algorithms for image processing case studies [PEO 2][PO-e]
4. Select the appropriate hardware and software tools (Contemporary) for image analysis and machine vision applications [PEO 5] [PO-k]

Unit I **[6 Hrs]**

Introduction and Digital Image Fundamentals

Introduction to image processing, origin, examples of fields, steps in image processing, components of image processing system, digital image fundamentals – elements of visual

perception, light and electromagnetic spectrum, image sensing and acquisition, mathematical tools used in image processing.

Unit II **[7 Hrs]**

Intensity Transformations, Spatial Filtering and Filtering in frequency domain

Basics intensity transformation functions, histogram processing, fundamentals of spatial filtering, smoothing and sharpening spatial filtering, combinations of image enhancement method, filtering in the frequency domain – Fourier transform of sample functions, DFT of one variable, extension to two variables, properties of 2 D DFTs, selective filtering, realization of FDT, FFT, filter design aspects.

Unit III **[8 Hrs]**

Image Restoration and Reconstruction, Segmentation

Model of the image degradation / restoration process, noise models, restoration in the presence of noise only – spatial filtering, periodic noise reduction by frequency domain filtering, estimating the degradation functions, inverse filtering, image reconstruction from projections. Image Segmentation - Image segmentation - point, line and edge detection, Thresholding, Regions Based segmentation, segmentation using morphological watersheds, usage of motion in segmentation, edge linking and boundary detection, Hough transform, chain codes, boundary segments, skeletons, boundary descriptors, Fourier descriptors

Unit IV **[7 Hrs]**

Image Compression

Image compression - image compression - data redundancies elements of information, variable-length coding, predictive coding, transform coding, image compression standards, wavelets and multi- resolution processing - image pyramids, sub-band coding.

Unit V **[7 Hrs]**

Object Recognition and Case studies

Object Recognition- patterns and pattern classes, recognition based on decision – theoretic methods, structural methods, case studies – image analysis

Unit VI **[7 Hrs]**

Machine Vision Applications

Interfacing of peripherals using Tiva: LED and sensors, ADC, Timer, PWM, UART, SPI, I2C.Development of web server, wireless module interfacing, camera interfacing, open CV on Beagle Bone Black. Control application, Java programming on Beagle Bone Black, porting android for mobile applications like controlling Beagle Bone Black I/O through mobile.

Text Books:

1. Gonzalez & Woods, “Digital Image Processing”, 3rd ed., Pearson education, 2008
2. Jain Anil K., “Fundamentals Digital Image Processing”, Prentice Hall India, 2010
3. Pratt W.K, “Digital Image Processing”, 3rd ed., John Wiley & Sons, 2007

Reference Books:

1. Milan Sonka, Vaclav Hlavav, Roger Boyle, "Image Processing, Analysis and Machine Vision", 2nd ed., Thomson Learning, 2001
2. Rangaraj M. Rangayyan, "Biomedical Image Analysis", CRC Press, 2005

(IE-18009) Project Stage II

Teaching Scheme:
Practical: 10 Hrs/week

Examination Scheme: 100 Marks
Continuous Evaluation: 50 Marks
Presentation/demonstration: 50 Marks

Course Outcomes:

1. 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 [PEO2] [PO-c]
2. Ability to work effectively in a various team (may be multidisciplinary teams) [PEO3][PO-d]
   An ability to understand social impact of automation, safety aspects and hazards associated with various processes in core instrumentation industry [PEO4][PO-f]

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.

(IE-18010) Seminar

Teaching Scheme:

Examination Scheme:
Continuous Evaluation: 50 Marks
Presentation/demonstration: 50 Marks

Course Outcomes:

1. Ability to understand of contemporary / emerging technology for various processes and systems [PEO2][PO-j]
2. An ability to share knowledge effectively in oral and written form and formulate documents [PEO3][PO-g]

Course Contents:

Seminar topic would be an emerging technology/ research/ product, study and finalization of the topic, sharing of knowledge with peers and discussion, documentation in the form of report.

(IE(HO)-18002) Process Dynamics and Control

Teaching Scheme:
Lectures :3 Hrs/week
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Examination Scheme:
Test 1- 20 Marks
Assignments/Quiz -20 Marks
End-Sem Exam- 60 Marks

Course Outcomes:

1. Knowledge of different process model [PEO1] [PO-1]
2. Implementation various control schemes for different processes using advanced control methods. [PEO2] [PO-2]
3. Implementation the communication protocol [PEO1] [PO-1]

Unit I **[8 Hrs]**

Process Instrumentation and Dynamics

Review of process characteristics, dead time analysis, capacity analysis, proportional integral and derivative control of dead time, combination of dead time and capacity

Unit II **[6 Hrs]**

Process Modeling

Types of models and modeling methods, modeling of process control systems in time domain and frequency domain

Unit III **[6 Hrs]**

System Identification 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 **[6 Hrs]**

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 **[6 Hrs]**

Object Recognition and Case studies

Cascade control , ratio control, selective control, split Range control, adaptive control techniques, model predictive control

Unit VI **[8 Hrs]**

Communication Protocol

Introduction to communication protocol ,modbus, RS 485/RS232, Ethernet, HART, CAN, Profibus and Foundation Fieldbus

Text Books:

1. F. G. Shinsky, "Process Control System," McGraw Hills, 1996.
2. B.G. Liptak , "Process Control", Chilton Publications, Fourth edition, 2009.

Reference Books:

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

(IE(MI)-18002) Industrial Instrumentation

Teaching Scheme:
Lectures : 3 Hrs/week

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

Course Outcomes:

1. Understanding of transmitters, convertors [PEO1][PO-l]
2. Selection of transmitter, convertor and final control element [PEO2][PO-c]
3. Develop proficiency in PLC programming skill for industrial application PEO1][PO-m]

Unit I: **[8 Hrs]**

Introduction of process loop components and standard symbols, Need of transmitter, Need for standardization of signals, concept of live & dead zero, Signal conditioning (analog & digital) for RTD, T/C, magnetic flow meter, DPT, span & zero adjustment, Electronic and pneumatic and differential Pressure Transmitter, calibration and application, SMART transmitter, Pneumatic to current converter, Current to pneumatic converter

Unit II: **[6 Hrs]**

On-Off, Proportional, integral, derivative, proportional-Integral, Proportional- Derivative, Proportional- Derivative-Integral, Anti-reset windup, Rate before reset Concept of bump less transfers in PID controller.

Unit III: **[6 Hrs]**

Tuning of controller, Quarter Amplitude Decay Ratio, Loop disturbance, stability criteria ,Open loop and closed loop tuning methods, set point tuning Vs load disturbance tuning, PID with limitations and tuning, digital controller (position & velocity algorithms, effect of sampling time), Digital PID controllers, block schematic of series and parallel combinations.

Unit IV: **[6 Hrs]**

Continuous versus Discrete Process Control, Architecture of PLC, ladder diagram using standard symbols, Types of Input & Output modules (AI, DI, AO, DO), wiring diagram, Specifications, manufacturers, PLC ladder diagram and instructions, PLC Programming for process applications

Unit V: **[6 Hrs]**

Control valve: Necessity, comparison with other final control elements, Classification of control valves Construction, Advantages, Disadvantages & applications of vales, types of actuators: Spring Diaphragm, Pneumatic, Hydraulic, Electro-hydraulic, Electric, and smart actuators, Control valve terminology, Inherent & installed chracteristics and Control valve accessories and Positioners Application/Need, Types

Unit VI: **[8 Hrs]**

Hazardous area classification & intrinsic safety, Explosion Proof Housing, Encapsulation, Sealing, & Immersion, Purging systems, Concept of safety cycle, HAZOP, fault tolerance and safety integrity level

Text Books:

1. Curtis Johnson , "Process Control and Instrumentation Technology, Prentice-Hall of India Fourth Edition, 1997
2. Norman A. Anderson , "Instrumentation for Process Measurement and Control", CRC Press, Third Edition, 1980
3. John W. Webb, "Programmable Logic Controllers", Prentice Hall, Fourth Edition, 1999

Reference Books:

1. B. Corripio, "Tuning of Industrial Control Systems, Publisher: ISA, Second Edition, 2001
2. William Andrews, "Applied Instrumentation in Process Industries", Gulf, Second Edition, 1979
3. Control Valve Handbook, Fisher Controls International, Inc. third Edition, 2001

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