PUDUCHERRY TECHNOLOGICAL UNIVERSITY
PUDUCHERRY–605014

(A Technological University of Government of Puducherry)

Curriculum and Syllabi

of

M.Tech. in Instrumentation Engineering

(With effect from Academic year 2020-21)

(Approved in the Sixth Academic Council Meeting held on 20th March 2021)

CURRICULUM

The curriculum of M.Tech. (**Instrumentation Engineering**) is designed to fulfill the Programme Educational Objectives (PEO) and Programme Outcomes (PO) listed below:

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

Master of Instrumentation Engineering curriculum is designed to prepare the graduates to acquire knowledge, skills and attitudes in order to

PEO1	Our graduates Excel in their preferred profession in government and private sectors..
PEO2	Involve in life-long learning and work as faculty members in reputed educational institutions, imparting knowledge and skills in the field of instrumentation engineering to the younger generations thereby producing talented engineers.
PEO3	Carry out ground-breaking research in emerging areas in the field of instrumentation engineering, and thereby solving various technical and societal problems at national and global levels.
PEO4	Our graduates emphasize on high degree of ethics with good communication skill to work collaboratively in groups, thus contributing immensely to the growth and development of entrepreneurship.

PROGRAMME OUTCOMES

PO	Key Word	Statements
PO1	**Engineering Knowledge**	Ability to apply knowledge of mathematics, science, and engineering.
PO2	**Problem Analysis**	Identify and formulate instrumentation Engineering problems from research literature and be able to analyse the problem using first principle of Mathematics and Engineering Sciences.
PO3	**Design/Development of Solutions**	Come out with solutions for the complex problems and to design system components or process that fulfil the particular needs taking into account public health and safety and the social, cultural and environmental issues.
PO4	**Conduct Investigations of Complex Problems**	Draw well-founded conclusions applying the knowledge acquired from research and research methods including design of experiments, analysis and interpretation of data and synthesis of information and to arrive at significant conclusion.
PO5	**Modern Tool usage**	From, select and apply relevant techniques, resources and Engineering and IT tools for Engineering activities like electronic prototyping, modelling and control of systems/ processes and also being conscious of the limitations.
PO6	**The Engineer and Society**	Understand the role and responsibility of the professional instrumentation Engineer and to assess societal, health, safety issues based on the reasoning received from the contextual knowledge.
PO7	**Environment and Sustainability**	Be aware of the impact of professional Engineering Solutions in societal and Environmental contexts and exhibit the knowledge and the need for sustainable Development.

PO8	**Ethics**	Apply the principle of professional Ethics to adhere to the norms of the engineering practice and to discharge ethical responsibilities.
PO9	**Individual and Team Work**	Function actively and efficiently as an efficiently as an individual or a member/leader of different teams and multidisciplinary projects.
PO10	**Communication**	Communicate efficiently the engineering facts with range of engineering community and others, to understand and prepare reports and design documents, to make effective presentations and to frame and follow instructions
PO11	**Project Management and Finance**	Demonstrate the acquisition of the body of engineering knowledge and insight and Management principles and to apply them as member/ leader in teams and multidisciplinary environments.
PO12	**Life-long Learning**	Recognize the need for self and life- long learning, keeping pace with technological challenges in the broadest sense

PROGRAMME SPECIFIC OUTCOMES (PSO)

PSO	Key Word	Statement
PSO1	**Live Problems of Industries**	Graduates possess an ability to recognize, adapt and to apply the knowledge of electronics and instrumentation to optimize Measurement systems to various applications.
PSO2	**Multidisciplinary Projects**	Graduates learn latest tools and apply them in the design and analysis of modern control systems.
PSO3	**Higher Studies and Entrepreneur**	Graduates can function in a Multidisciplinary Environment by being able to associate and integrate their domain knowledge with other disciplines.

Distribution of Credits among the subjects grouped under various categories:

Courses are grouped under various categories and the credits to be earned in each category of courses are as follows:

Sl. No.	Category	Credits	Course Category Code (CCC)
1	Programme Core Course	24	PCC
2	Programme Specific Elective Courses	15	PSE
3	Open Elective Courses	03	OEC
4	Professional Activity Courses (Project Work, Seminar)	28	PAC
5	Mandatory Audit Courses	Non - Credit	MAC
	Total	**70**	

Semester Wise Courses and Credits

Semester I

Course Code	Course	CCC	Periods			Credits
			L	T	P	
EI251	Advanced Process Control	PCC	3	0	0	3
EI252	Transducers For Instrumentation	PCC	3	0	0	3
EI253	Applied Industrial Instrumentation	PCC	3	0	0	3
EIZNN	Programme Specific Elective - 1	PSE	3	0	0	3
EIZNN	Programme Specific Elective - 2	PSE	3	0	0	3
EI254	Process Control and Instrumentation Lab	PCC	0	0	4	2
EI255	Research Methodology and IPR	PCC	2	0	0	2
AD2NN	Audit Course - I	MAC	2	0	0	0
Total			**23**			**19**

Semester II

Course Code	Course	CCC	Periods			Credits
			L	T	P	
EI256	Instrumentation System Design	PCC	3	0	0	3
EI257	PLC &DCS	PCC	3	0	0	3
EI258	Real Time Embedded System Design	PCC	3	0	0	3
EIZNN	Programme Specific Elective - 3	PSE	3	0	0	3
EIZNN	Programme Specific Elective - 4	PSE	3	0	0	3
EI259	Industrial automation and Embedded System Design Lab	PCC	0	0	4	2
EI260	Mini Project and Seminar	PAC	0	0	4	2
AD2NN	Audit Course - II	MAC	2	0	0	0
Total			**25**			**19**

Semester III

Course Code	Course	CCC	Periods			Credits
			L	T	P	
EIZ05	Programme Specific Elective - 5	PSE	3	0	0	3
OE2NN	Open Elective	OEC	3	0	0	3
EI261	Dissertation – Phase I	PAC	0	0	20	10
Total			**26**			**16**

Semester IV

Course Code	Course	CCC	Periods			Credits
			L	T	P	
EI262	Dissertation – Phase II	PAC	0	0	32	16
Total			**32**			**16**

Audit Courses (MAC)

AD201	English for Research Paper Writing
AD202	Disaster Management
AD203	Value Education
AD204	Constitution of India
AD205	Pedagogy Studies
AD206	Stress Management by Yoga

Open Elective Courses (OEC)

OE201	Business Analytics (IT)
OE202	Industrial Safety and Maintenance (ME)
OE203	Operations Research (ME)
OE204	Cost Management of Engineering Projects (CE)
OE205	Composite Materials (PH)
OE206	Waste to Energy (CE)

Programme Specific Electives (PSE):

PSE - 1	**EIZ01**	Linear and Nonlinear Systems Theory
	EIZ02	Advanced Image Processing
	EIZ03	Virtual Instrumentation
	EIZ04	Data Analytics for Instrumentation Engineers
PSE -2	**EIZ05**	Advanced Biomedical Instrumentation
	EIZ06	Artificial Intelligence & Deep Learning
	EIZ07	Industrial Drives and Control
	EIZ08	VLSI System Design
PSE -3	**EIZ09**	Industrial IoT
	EIZ10	System Identification
	EIZ11	Robotics and Automation
	EIZ12	Robust Control
PSE - 4	**EIZ13**	Thermal Power Plant Instrumentation
	EIZ14	MEMS
	EIZ15	Adaptive Control
	EIZ16	Active fault tolerant Control
PSE - 5	**EIZ17**	Instrumentation in Petrochemical Industries
	EIZ18	Optimal State Estimation
	EIZ19	Optimal Control
	EIZ20	Automotive Instrumentation

XX – Department Code; **NN** – Running Number; **N** – Running Number

Department: Electronics and Instrumentation Engineering		Programme: **M.Tech. Instrumentation Engineering**							
Semester: I		Course Category Code:				Semester Exam Type: **TY**			
Course Code	Course Name	Periods / Week			Credit	Maximum Marks			
		L	**T**	**P**		**CA**	**SE**	**TM**	
EI251	**ADVANCED PROCESS CONTROL**	3	-	-	3	40	60	100	
Prerequisite	CONTROL and INSTRUMENTATION								
Course Objectives	**CO1**								
	CO2								
	CO3								
	CO4								
	CO5								

UNIT I	**PROCESS DYNAMICS AND CONTROL ACTIONS**:	**Periods** : **9**
Process dynamics: Degrees of freedom , servo and regulatory responses, self regulation – Mathematical model of processes – Linearization of nonlinear systems – Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Digital PID algorithm – Auto/manual transfer - Reset windup - Selection of control modes - Evaluation criteria: IAE, ISE, ITAE and ¼ decay ratio - Controller tuning – Auto tuning – Final Control element: Control valve types, Characteristics and selection criteria.		**CO1**
UNIT II	**ADVANCED CONTROL CONFIGURATIONS**:	**Periods** : **9**
Control systems with multiple loops: Cascade control, Selective control systems, split range control, feed-forward control, ratio control, adaptive control, inferential control - Multivariable Control: Interaction of control loops, pairing of Inputs and outputs, Relative Gain Array (RGA), multi-loop PID Controller, decoupling of control loops - Model based Control: Smith predictor control scheme, internal model control and introduction to model predictive control.		**CO2**
UNIT III	**DIGIRAL CONTROL SYSTEM:**	**Periods** : **9**
Basic buildingblocksofcomputercontrolsystem–Pulsetransferfunction–Modifiedz-transform- Digital PID controller – Position and velocityform–Deadbeat'salgorithm–Dahlin'salgorithm–Kalman'salgorithm - Pole placement controller – Predictive controller.		**CO3**
UNIT IV	**PROGRAMMABLE LOGIC CONTROLLER (PLC):**	**Periods** : **9**
Overview of PLC system – Input / Output modules - PLC programming languages - Basic relay logic functions - Timer/Counter functions - Arithmetic functions - Comparison functions - Skip and MCR functions - Data transfer functions - Matrix functions - Sequencer function - Analog PLC operation - PID function - Alternate programming languages - Design of interlocks and alarms using PLC - PLC applications- Safety PLC- Process safety management during start up and shut down.		**CO4**
UNIT V	**DISTRIBUTED CONTROL SYSTEM AND INDUSTRIAL COMMUNICATION STANDARDS:**	**Periods** : **9**
Introduction - Evolution of DCS- DCS architecture – Local control unit - Operator interface – Displays - Engineering interface - Redundancy concept - Factors to be considered in selecting DCS - Communication facilities: HART protocol, Foundation Field bus, Profibus, Industrial Ethernet, Profinet.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books
1.Stephanopoulos G, "Chemical Process Control", Pearson Education India, New Delhi, 2015. 2.Dale E. Seborg, Thomas F. Edgar, Duncan A Mellichamp and Francis J. Doyle. "Process Dynamics and Control", John Wiley and sons, Fourth Edition, 2016 3.Frank D Petruzella, "Programmable Logic Controllers", McGraw Hill, Fifth Edition, 2019. 4.MoustafaElshafei, "Modern Distributed Control Systems: A comprehensive coverage of DCS technologies and standards", Amazon Digital Services, 2016 5.Lawrence M. Thompson, Tim Shaw, "Industrial Data Communications", ISA, Fifth Edition, 2015.

MAPPING OF ADVANCED PROCESS CONTROL OUTCOMES WITH PROGRAMME OUTCOMES

CO/PO/ PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO252.1	3		3	2		1		3	
CO252.2	3		3	2				3	
CO252.3	3		3	2				3	
CO252.4	3		3	2				3	
CO252.5	3		3	2				3	

Department: Electronics and Instrumentation Engineering		Programme: **M.Tech. Instrumentation Engineering**	
Semester: I		Course Category Code:	Semester Exam Type: **TY**

Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
EI252	**TRANSDUCERS FOR INSTRUMENTATION**	3	-	-	3	40	60	100
Prerequisite	Measurements and instrumentation							

Course Objectives	**CO1**	To impart knowledge on transducer characteristics.
	CO2	To make the students understand the importance of error analysis and to determine the Uncertainties associated with measuring instruments.
	CO3	To make the students understand the importance of smart sensor technologies and familiarization of standards for smart sensor Interface
	CO4	To provide exposure to manufacturing techniques and different types of Micro sensors and actuators
	CO5	To provide an overview of latest advancement and trends in transducers and smart instruments.

UNIT I	**Measurement Systems: Definition of terminologies**	**Periods** : **9**	
Generalized performance Characteristics (Static and Dynamic) – Dynamic Response of Transducers (Transient and Frequency Domain). Mechanical Input Characteristics: Spring, damping, Pressure sensitive components, Active and Passive transducers			**CO1**
UNIT II	**Resistance Transducers**	**Periods** : **9**	
Resistance potentiometer – noise – Nonlinearity – resolution. Strain gauges – Gauge factor - associated electrical circuitry- temperature compensation – load cells – torque and pressure measurement using strain gauges.Strain-to-frequency converter. Resistance thermometers – three-lead arrangement – Thermistors – linearization. Hotwire anemometers – time constant improvement – measurement of direction of flow.			**CO2**
UNIT III	**Reactance Transducers**	**Periods** : **9**	
Inductance Transducers: General factors governing the design of self-inductance transducers – transverse armature and plunger type- sensitivity and nonlinearity – Associated bridge circuits –choice of components. LVDT – Expression for mutual inductance variation – null voltage – lead and lag networks – Blumlein Bridges- applications of LVDTs.**Capacitance Transducers:** Various configurations – sensitivity and nonlinearity factors – associated signal conditioning circuits.			**CO3**
UNIT IV	**Active Transducers & Force-Balance Transducers**	**Periods** : **9**	
Active transducers: Definition – General type pickups, thermocouples –Piezoelectric sensors – use of charge amplifiers with piezoelectric sensors. Dynamic performances. **Seismic Pickups:** Transfer function and frequency response. Types of Accelerometers. **Force-Balance Transducers:** Theory-servo systems for measurement of non-electrical quantities.			**CO4**
UNIT V	Digital and Intelligent Sensors	**Periods** : **9**	
Position Encoders: Incremental position encoders, Absolute position encoders, Digital Tachometers, Biosensors. SAW sensors,IC Temperature Sensors COMMUNICATION SYSTEMS FOR SENSORS: Current telemetry: 4 to 20 mA loop, Simultaneous analog and digital communication (HART),Sensor buses: Fieldbus, Intelligent Sensors.			**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Course Outcome	**CO1**	Ability to categorize and characterize a conventional transducer.
	CO2	Ability to analyze and quantify the uncertainties in measurement data
	CO3	Ability to design smart sensors with special features
	CO4	Acquire a comprehensive Knowledge of manufacturing techniques and design aspects of micro sensors and actuators
	CO5	Keep abreast of latest sensor technology and advanced measurement methodologies and able to suggest a proper transducer for an application

Reference Books

1 K. Neubert, 'Instrument Transducers-An introduction to their performanceand design' Oxford University press, Oxford, Second edition-2003.

2.Ramon Pallas-Areny, John G. Webster," Sensors and Signal Conditioning,JOHN WILEY, 2nd Edition-2001.

3. Ernest O Doebelin and Dhanesh N Manik, "Measurement Systems Application and Design", 6thEdition, Tata Mc-Graw Hill, 2011.

MAPPING TRANSDUCERS FOR INSTRUMENTATIONOUTCOMES WITH POs and PSOs

CO/PO/PSO	PO01	PO02	PO03	PO04	PO05	PO06	PSO1	PSO2	PSO3
CO252.1	2	2	3	3	2	1	3	2	3
CO252.2	3	3	3	1	1	1	3	3	2
CO252.3	2	1	3	3	1	1	3	1	3
CO252.4	1	1	3	3	1	2	3	3	2
CO252.5	1	1	1	1	1	3	2	1	3

<table>
<tr><td colspan="3">Department: Electronics and Instrumentation Engineering</td><td colspan="8">Programme: M.Tech. Instrumentation Engineering</td></tr>
<tr><td colspan="3">Semester: I</td><td colspan="4">Course Category Code:</td><td colspan="4">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td colspan="2" rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="4">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td colspan="2">TM</td></tr>
<tr><td>EI253</td><td colspan="2">Applied Industrial Instrumentation</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td colspan="2">100</td></tr>
<tr><td>Prerequisite</td><td colspan="10">Measurements and instrumentation</td></tr>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td colspan="9">To enable the students to acquire knowledge about the various techniques used for the Measurement of primary industrial parameters like flow, level, temperature and pressure</td></tr>
<tr><td>CO2</td><td colspan="9">To understand the important parameters to be monitored and analysed in Thermal power Plant</td></tr>
<tr><td>CO3</td><td colspan="9">To get an exposure on the important parameters to be monitored and analyzed in Petrochemical Industry.</td></tr>
<tr><td>CO4</td><td colspan="9">Ability to apply the instrumentation concepts in environment</td></tr>
<tr><td>CO5</td><td colspan="9">Ability to get knowledge about instrumentation in intrinsic safety techniques adapted in industries and special purpose instruments</td></tr>
<tr><td>UNIT I</td><td colspan="7">Review Of Industrial Instrumentation</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="10">Measurement of Force, Torque, Velocity, Acceleration, Pressure, Temperature, Flow, Level, Viscosity, Humidity & Moisture (Qualitative Treatment Only).</td><td>CO1</td></tr>
<tr><td>UNIT II</td><td colspan="7">Measurement in Thermal Power Plant</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="10">Selection, Installation and maintenance of Instruments used for the measurement of fuel flow, Air flow, Drum level, Steam pressure, Steam temperature and other parameters in thermal power plant – Analyzers-Dissolved Oxygen Analyzers- Flue gas Oxygen Analyzers-pH measurement- Coal/Oil Analyzer – Pollution Controlling Instruments.</td><td>CO2</td></tr>
<tr><td>UNIT III</td><td colspan="7">Measurement in Petrochemical Industry</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="10">Parameters to be measured in refinery and petrochemical Industry-Temperature, Flow and Pressure Measurements in Pyrolysis, catalytic cracking, reforming Processes-Selection and maintenance of measuring instruments – Intrinsic safety.</td><td>CO3</td></tr>
<tr><td>UNIT IV</td><td colspan="7">Instrumentation for environmentalanalysis</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="10">Measurement techniques for water quality parameters - conductivity - temperature - turbidity. Measurement techniques for chemical pollutants - chloride - sulphides - nitrates and nitrites - phosphates - fluoride - phenolic compounds</td><td>CO4</td></tr>
<tr><td>UNIT V</td><td colspan="7">Instrumentation for safety& Special Purpose Instrumentation</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="10">Safety: Introduction, electrical hazards, hazardous areas and classification, non-hazardous areas, enclosures – NEMA types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety. Toxic gas monitoring- Detection of Nuclear radiation – Thermo-luminescent detectors – Measurement of length, mass, thickness, flow, level using nuclear radiation.</td><td>CO5</td></tr>
<tr><td colspan="2">Lecture Periods: 45</td><td colspan="3">Tutorial Periods: -</td><td colspan="3">Practical Periods: -</td><td colspan="3">Total Periods: 45</td></tr>
<tr><td colspan="11"><u>Reference Books</u></td></tr>
<tr><td colspan="11">1. D.Patranabis, Principles of Industrial Instrumentation, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1999.
2. John G Webster, Measurement, Instrumentation and Sensors Handbook, CRC press IEEE press
3. LiptakB.G, Instrumentation Engineers Handbook (Measurement), Chilton Book Co., 1994.
4. Reay D.A, Industrial Energy Conservation, Pergamon Press,1977.
5. Hodge B.K, Analysis and Design of energy systems, Prentice Hall, (1988).</td></tr>
</table>

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	1	1	1	1	-	-	-	-	-	-	-	-	-	-
CO2	2	1	1	1	1	-	-	-	-	-	-	-	-	-	-
CO3	2	2	1	2	2	-	-	-	-	-	-	-	-	-	-
CO4	2	2	1	2	2	-	-	-	-	-	-	-	-	-	-
CO5	2	3	1	2	2	-	-	-	-	-	-	-	-	-	-

Score: **3** – High; **2** – Medium; **1** – Low

Department : Electronics and InstrumentationEngineering			Programme : M.Tech. (Instrumentation Engineering)						
Semester	I		**Category** : LB						
Subject Code	Subject	Hours / Week			Credit	Maximum Marks			
		L	**T**	**P**	**C**	**CA**	**SE**	**TM**	
EI254	**Process Control and Instrumentation Laboratory**	-	-	3		60	40	100	

List of Experiments

1. Identification of linear dynamic model of a process using non parametricmethods.
2. (a) Design and implementation PID Control scheme on simulatedprocess.
   (b) PID Implementationissues
3. Level and pressure control (with and without Interaction) in process control TestRig.
4. (a) Auto- Tuning of PIDcontroller
   (b)Design and implementation of gain scheduled Adaptive controller on the simulated model of variable area tank process.
5. Design and implementation of Feed forward and Cascade control schemes on the simulated model of CSIR process.
6. (a) Analysis of MIMOsystem.
   (b)Design and implementation of Multi-loop PID and Multivariable PID control schemes on the simulated model of two-tank systems.
7. Design and implementation of Robust PID control schemes on the simulated model of variable area tank process.
8. Designand implementationof SelftuningandModelReferenceAdaptiveControlschemesonthe simulated model of variable area tankprocess.
9. Design and Implementation of Digital pHmeter
10. Design and Implementation of Cold Junction CompensatedThermocouple
11. Design and Implementation of Digital Thermometer using RTD, Thermocouple andAD590
12. Design and Implementation of Smart Digital Energymeter
13. Design and Implementation of Single Board FunctionGenerator
14. Design, testing and calibration of programmableTimers.
15. Design and testing of advanced measurementcircuits.

Total contact Hours:	Total Tutorials: -	Total Practical Classes: 45	Total Hours: 45

<table>
<tr><td colspan="2">Department: Electronics and Instrumentation Engineering</td><td colspan="8">Programme: M.Tech. Instrumentation Engineering</td></tr>
<tr><td colspan="2">Semester: I</td><td colspan="4">Course Category Code:</td><td colspan="4">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EI255</td><td>Research Methodology and IPR</td><td>2</td><td>-</td><td>-</td><td>2</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">Control Systems</td></tr>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td colspan="7">Understanding and formulation of research problem.</td></tr>
<tr><td>CO2</td><td colspan="7">Ability to proposal for the research Understand plagiarism and follow research ethics</td></tr>
<tr><td>CO3</td><td colspan="7">To grab the knowledge in Nature of Intellectual Property</td></tr>
<tr><td>CO4</td><td colspan="7">To understand the importance of Patent Rights</td></tr>
<tr><td>CO5</td><td colspan="7">To know the recent trends in IPR</td></tr>
<tr><td>UNIT – I</td><td colspan="5">Identification of problem</td><td colspan="3">Periods : 6</td></tr>
<tr><td colspan="8">Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.</td><td>CO1</td></tr>
<tr><td>UNIT II</td><td colspan="5">literature studies and Research Proposal</td><td colspan="3">Periods : 6</td></tr>
<tr><td colspan="8">Effective literature studies approaches, analysis Plagiarism, Research ethics. Effective technical writing, how to write report, Developing a Research Proposal, Format of research proposal, presentation and assessment by a review committee.</td><td>CO2</td></tr>
<tr><td>UNIT III</td><td colspan="5">Intellectual Properties</td><td colspan="3">Periods : 6</td></tr>
<tr><td colspan="8">Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT</td><td>CO3</td></tr>
<tr><td>UNIT IV</td><td colspan="5">Patent Rights</td><td colspan="3">Periods : 6</td></tr>
<tr><td colspan="8">Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.</td><td>CO4</td></tr>
<tr><td>UNIT V</td><td colspan="5">New Developments in IPR</td><td colspan="3">Periods : 6</td></tr>
<tr><td colspan="8">Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge, Case Studies.</td><td>CO5</td></tr>
<tr><td colspan="2">Lecture Periods: 30</td><td colspan="2">Tutorial Periods: -</td><td colspan="2">Practical Periods: -</td><td colspan="3">Total Periods: 30</td></tr>
<tr><td colspan="9"><u>Reference Books</u></td></tr>
<tr><td colspan="9">1. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
2. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
1. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
2. Mayall , “Industrial Design”, McGraw Hill, 1992.
3. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
4. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008.</td></tr>
</table>

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	1	1	1	3	3	3	3	3	1	-	2	1	3	3	3
CO2	2	2	1	3	3	1	1	3	1	-	-	-	3	3	3
CO3	2	1	3	2	2	1	1	3	2	-	1	-	3	3	3
CO4	2	1	1	2	2	1	1	3	2	1	1	-	3	3	3
CO5	2	1	1	1	2	1	1	3	2	-	-	2	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

Department: Electronics and Instrumentation Engineering		Programme: **M.Tech. Instrumentation Engineering**						
Semester: II		Course Category Code:			Semester Exam Type: **TY**			
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	**T**	**P**		**CA**	**SE**	**TM**
EI256	**INSTRUMENTATION SYSTEM DESIGN**	3	-	-	2	40	60	100
Prerequisite	Process Control/ Systems, Analog and digital circuits design							

Course Objectives	**CO1**	To impart knowledge on the design of signal conditioning circuits for the measurement of Level, temperature and pH.
	CO2	To develop the skills needed to design, fabricate and test Analog/ Digital PID controller
	CO3	Data Loggers and Alarm Annunciator
	CO4	To make the students familiarize with regard to orifice sizing and control valve sizing
	CO5	

UNIT – I	**DESIGN OF SIGNAL CONDITIONING CIRCUITS**	**Periods** : **9**
Design of V/I Converter and I/V Converter- Analog and Digital filter design and Adaptive filterdesign – Signal conditioning circuit for pH measurement, Air-purge Level Measurement –Signal conditioning circuit for Temperature measurement: Thermocouple, RTD and Thermistor - Cold Junction Compensation and Linearization:– Software and Hardware approaches. .		**CO1**
UNIT II	**DESIGN OF TRANSMITTERS**	**Periods** : **9**
Design of 2 wire and 4 wire transmitters:–RTD based Temperature Transmitter, Thermocouple based Temperature Transmitter, Capacitance based Level Transmitter, Smart Flow Transmitters and IoT enabled transmitters		**CO2**
UNIT III	**DESIGN OF DATA LOGGER AND PID CONTROLLER**	**Periods** : **9**
Micro - controller based Data Logger - Design of PC based Data Acquisition Cards - Design of ON / OFF Controller using Analog Circuits - Electronic PID Controller – Microcontroller Based PID Controller.		**CO3**
UNIT IV	**DESIGN OF ALARM AND ANNUNCIATION CIRCUIT**	**Periods** : **9**
Alarm and Annunciation circuits using Analog and Digital Circuits – Design of Programmable Logic Controller - Design of configurable sequential controller using PLDs		**CO4**
UNIT V	**ORIFICE AND CONTROL VALVE SIZING**	**Periods** : **9**
Orifice, Venturi and flow nozzle Sizing: - Liquid, Gas and steam services – Control valve sizing – Liquid, Gas and steam Services and Standards		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Course Outcome	**CO1**	Competence to design signal conditioning circuits for temperature sensors, V/I and I/V converters
	CO2	Ability to design, fabricate and test smart transmitters
	CO3	Ability to design, fabricate and test PID controllers
	CO4	Ability to carry out orifice and control valve sizing for Liquid/Steam Services
	CO5	Exposure to simulation tools such as MATLAB and Capability to deign PLC and alarm circuits

Reference Books

1 C. D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Prentice Hall,2014.

2 Control Valve Handbook, 4thEdition, Emerson Process Management, Fisher Controls International, 2005.

3 R.W. Miller, "Flow Measurement Engineering Handbook", Mc-Graw Hill, New York 1996.

4 Bela G. Liptak, "Instrument Engineers Handbook - Process Control and Optimization", 4thEdition, Vol.2, CRC Press,2008.

5 Thakore and Bhatt ,"Introduction to Process Engineering and Design" , TATA McGraw-Hill, 2007.

MAPPING INSTRUMENTATION SYSTEM DESIGN OUTCOMES WITH POs and PSOs

CO/PO/ PSO	PO 01	PO 02	PO 03	PO 04	PO 05	PO 06	PS O1	PS O2	PS O3
CO256.1			3					3	
CO256.2			3	3	3				3
CO256.3				1	1				
CO256.4				3	3			3	
CO256.5				3	3			3	

<table>
<tr><td colspan="3">Department: Electronics and Instrumentation Engineering</td><td colspan="7">Programme: M.Tech. Instrumentation Engineering</td></tr>
<tr><td colspan="3">Semester: II</td><td colspan="4">Course Category Code:</td><td colspan="3">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td colspan="2" rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EI257</td><td colspan="2">PLC and DCS</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="9">Sensor/ transducer, field transmitters, basic instrumentation and process control</td></tr>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td colspan="8">Ability to understand all the important components of PLC and field devices of an industrial automation system</td></tr>
<tr><td>CO2</td><td colspan="8">Ability to develop PLC program in different languages for industrial sequential applications.</td></tr>
<tr><td>CO3</td><td colspan="8">Analyze current philosophy, technology, terminology, and practices used in automation industries.</td></tr>
<tr><td>CO4</td><td colspan="8">Understand the basics of DCS and interfacing methods with DCS</td></tr>
<tr><td>CO5</td><td colspan="8">Ability to understand the advance communication protocol in instrumentation</td></tr>
</table>

UNIT I	**Basics of PLC Programming**	**Periods : 9**
Introduction to PLC - Configuration of PLC(components for modularized PLC)- Architecture of PLC - Working of PLC- PLC peripherals- PLC symbols- Selection criteria of PLC- Advantages and disadvantages of PLC- Analog input/ output module- Digital input/ output module- Special I/O Modules, I/O Specifications- Switching devices (level, pressure, flow, temperature, timer, proximity switch).- PLC input/output connection- PLC power connection (wiring)- Isolated and non-isolated input/output wiring to PLC. PLC applications.		**CO1**
UNIT II	**Basics of PLC Programming**	**Periods : 9**
Basics of PLC programming – Ladder Logic – Relay type instructions – Timer/Counter instructions -Program control instructions –Datamanipulationand math instructions – Programming Examples. Functional block programming – Sequential function chart – Instruction list – Structured text programming -PLC controlled sequential Process Examples.		**CO2**
UNIT III	**Networking of PLC and SCADA**	**Periods : 9**
Networking ofPLCs –Network communication –OSI Model types –OPC function. Supervisory Control and Data Acquisition –Architecture –development and runtime mode functions, Tools –tag database, recipe database –log, trace –alarm logging –Trend –on line, off line –Security and user access management, Management Information System–report function.		**CO3**
UNIT IV	**Distributed Control System**	**Periods : 9**
DCS -Architectures –Comparison –Local control unit –Process interfacing issues –Communicationfacilities.Operator interfaces -Low level and high level operator interfaces –Operator displays –Engineeringinterfaces –Low level and high level engineering interfaces General purpose computers in DCS.		**CO4**
UNIT V	**Communication Protocol**	**Periods : 9**
Introduction HART communication protocol – communication modes - HART networks – HART commands – HART application – Fieldbus: Introduction – fieldbus architecture, Basic requirements of field bus standard – fieldbus topology – Interoperability and Interchangeability. Smart Transmitters – MAP protocol.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Frank. D.Petrezuella , Programmable logic controllers, McGrewhill, Third edition.
2. Lucas. M.P., Distributed control systems ,VanNostrand and Reinholdcompany, NY,1986.
3. Hughes.T., Programmable controllers, ISA Press, 2000
4. M. Chidambaram , Computer control of process, Narosa publishing house.
5. D.M.Considine, Process Instruments and Controls Handbook, McGraw-Hill., 1985.
6. Moore, Digital control devices, ISA press, 1986.
7. B.G.Liptak, Instrumentation in process industries, Vol. I and II, Chilton books co,1973.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	1	1	1	1	-	-	-	-	-	-	-	-	-	-
CO2	2	1	1	1	1	-	-	-	-	-	-	-	-	-	-
CO3	2	2	1	2	2	-	-	-	-	-	-	-	-	-	-
CO4	2	2	1	2	2	-	-	-	-	-	-	-	-	-	-
CO5	2	3	1	2	2	-	-	-	-	-	-	-	-	-	-

Score: **3** – High; **2** – Medium; **1** – Low

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<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EI258</td><td>Real Time Embedded System Design</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">Microprocessors and Applications</td></tr>
</table>

<table>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td>Ability to design activation circuit for any generic embedded microcontroller.Preliminary design considerations for system level implementation.</td></tr>
<tr><td>CO2</td><td>Ability to understand firmware development cycle and to develop firmware using Embedded ‘C’ platform.</td></tr>
<tr><td>CO3</td><td>Ability to understand the architecture of ARM7 Processor, hardware features and internal peripherals working and Special function registers in LPC2148 microcontroller.</td></tr>
<tr><td>CO4</td><td>Ability to design embedded systems using LPC2148 microcontroller using a range of input and output peripherals.</td></tr>
<tr><td>CO5</td><td>Ability to use Real Time Operating Systems for time critical embedded systems. Ability to port a RTOS for a real time problem.</td></tr>
</table>

<table>
<tr><td>UNIT I</td><td>REVIEW OF EMBEDDED SYSTEMS</td><td>Periods : 9</td></tr>
<tr><td colspan="2">Review of Embedded Systems –Role of Microcontrollers in Embedded System design – Features of Microcontrollers –Processor Selection criteria –Word length – Performance Issues - Power consumption – Package Types – Electrical requirements – Reset Hardware – oscillator Design – power Consideration - Development Tools.</td><td>CO1</td></tr>
<tr><td>UNIT II</td><td>FIRMWARE DEVELOPMENT FOR EMBEDDED SYSTEMS</td><td>Periods : 9</td></tr>
<tr><td colspan="2">Firmware Development options – Assembly Language Vs High level Language Programming- Intel Hex File Format - Firmware development using Embedded C – introduction to data types – conditional statements – loops – functions. Using pointers for firmware development.</td><td>CO2</td></tr>
<tr><td>UNIT III</td><td>LPC2148 Microcontroller</td><td>Periods : 9</td></tr>
<tr><td colspan="2">ARM 7 Architecture –LPC2148 microcontroller introduction – Internal memory map - Peripheral details – Implementation of GPIO, Timer/Counter, UART, Interrupt architecture – ADC and DAC – Development of device drivers using embedded C.</td><td>CO3</td></tr>
<tr><td>UNIT IV</td><td>SYSTEM DESIGN USING LPC2148 MCU</td><td>Periods : 9</td></tr>
<tr><td colspan="2">Design of Simple I/O systems, Current source and sink concepts - Interfacing Character and Graphical LCD Displays – DC Motor Speed Control System – Speed Measurement – Design of Digital Frequency meter - Interfacing with communication devices –PC based Control systems</td><td>CO4</td></tr>
<tr><td>UNIT V</td><td>REAL TIME OPERATING SYSTEM</td><td>Periods : 9</td></tr>
<tr><td colspan="2">Concept of Real Time Operating Systems – Real Time Systems - Hard real time Vs Soft Real Time Systems – Single Tasking Vs Multitasking - Scheduling in RTOS –Types of Scheduling-Cooperative Vs Preemptive scheduling – RTOS Kernel Services – Task management - Task and Resource Synchronization, Inter Task communication, Timer Management, Memory Management, Interrupts and Events Handling. Examples using RTOS.</td><td>CO5</td></tr>
</table>

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Michael J Pont,"Patterns for Time-Triggered Embedded Systems", Addison-Wesley Professional,2001.
2. Trevor Martin,”The Insider's Guide to the Philips ARM7-Based Microcontrollers”,HitexPubications(UK),2005.
3. Richard Barry,"Using the FreeRTOS Real Time Kernel, A Practical Guide", Real Time Engineers Ltd, 2016.
4. Phillip A. Laplante, ‘Real-Time Systems Design and Analysis: An Engineer's Handbook’, Wiley Publications,2004

<u>CO – PO Mapping</u>

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	3	1	1	-	-	-	1	-	2	3	3	3	3
CO2	3	3	3	1	3	-	-	3	2	-	3	3	3	3	3
CO3	3	3	3	1	3	-	-	1	3	-	3	3	3	3	3
CO4	3	3	2	1	3	-	-	1	3	-	3	3	3	3	3
CO5	3	1	2	1	3	-	-	1	3	-	3	3	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

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<tr><td colspan="2">Semester: II</td><td colspan="4">Course Category Code:</td><td colspan="3">Semester Exam Type: LB</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EI259</td><td>Industrial automation and Embedded System Design Lab</td><td>-</td><td>-</td><td>4</td><td>2</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">Microcontroller and process control</td></tr>
</table>

Course Outcome	**CO1**	To Design microcontroller based Embedded systems.
	CO2	To develop firmware for the systems and to validate the same through functional simulation and hardware verification.
	CO3	To understand practical issues of applications of PLC hardware and programming a PLC.
	CO4	To get adequate knowledge about practical issues of implementations of PLC and DCS.
	CO5	To get adequate knowledge about practical issues of calibration of Process instruments

List of Experiments

Part-A Embedded Systems — **CO1,CO2,**

1. Parallel Port Interfacing Using MCS51
2. Design of Real Time Clock using MCS 51 using segment Displays
3. Design of PC interface Hardware with MCS51
4. Interfacing LCD Display using MCS51
5. Design of Single Channel Data Acquisition System Using MCS51
6. Implementation of GPIO and Timer using ARM LPC2148
7. Implementation of UART features of ARM LPC2148
8. Implementation of Data Acquisition and Signal Generation using LPC2148
9. Interfacing SD card and Graphical LCD using LPC2148
10. Implementation of USB communication using LPC2148

Part-B Industrial Automation — **CO3, CO4 CO5**

1. Design and simulation of digital controller using Kalman's algorithm
2. PC based PID Control of 4th order electronic process using C program
3. Study of basic programming of PLC and Analog operation in PLC
4. Arithmetic operation, Timer, Counter operation using PLC and Annunciator design using PLC
5. Programming practices in CODESYS.
6. DCS based control of Level Process , Temperature Process

Lecture Periods: 0	**Tutorial Periods: -0**	**Practical Periods: - 60**	**Total Periods: 60**

Reference Books

1. David E Simon, " An embedded software primer ", Pearson education Asia, 2001.
2. Trevor Martin,"The Insider's Guide to the Philips ARM7-Based Microcontrollers",Hitex Pubications(UK),2005.
3. Michael J Pont,"Patterns for Time-Triggered Embedded Systems",Addison-Wesley Professional,2001.
4. Phillip A. Laplante, "Real-Time Systems Design and Analysis: An Engineer's Handbook", Wiley Publications, 2004.
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<u>CO – PO Mapping</u>

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CO1	3	3	3	3	3	-	-	-	-	-	-	-	3	3	3
CO2	3	3	3	3	3	-	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	-	3	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	3	3
CO5	3	3	3	3	3	-	-	-	-	-	-	-	3	3	3

<u>Score</u>: **3** – High; **2** – Medium; **1** – Low

<table>
<tr><td colspan="2">Department :Electronics and Instrumentation Engineering</td><td colspan="7">Programme : M.Tech. (Instrumentation Engineering)</td></tr>
<tr><td colspan="2">Semester :III</td><td colspan="7">Category :PR</td></tr>
<tr><td rowspan="2">Subject code</td><td rowspan="2">Subject</td><td colspan="3">Hours/week</td><td>Credit</td><td colspan="3">Maximum marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td>C</td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EI260</td><td>Dissertation – Phase I</td><td>-</td><td>-</td><td>-</td><td>10</td><td>150</td><td>150</td><td>300</td></tr>
<tr><td>Prerequisite</td><td colspan="8">-</td></tr>
<tr><td>Objectives</td><td colspan="8">To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes.</td></tr>
<tr><td>Outcomes</td><td colspan="8"></td></tr>
<tr><td colspan="9">The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research. The project work should be a project in control and Instrumentation stream. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. Department will constitute an Evaluation Committee to review the project work. The student is required to undertake project phase-I during the third semester and the same is continued in the 4th semester (Phase-II).</td></tr>
<tr><td colspan="9"></td></tr>
</table>

PROGRAMME SPECIFIC ELECTIVE

Department: Electronics and Instrumentation Engineering			Programme: **M.Tech. Instrumentation Engineering**						
Semester:			Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
EIZ01	**Linear and Nonlinear System Theory**		**3**	**-**	**-**	**3**	**40**	**60**	**100**
Prerequisite	Control Systems								
Course Outcome	**CO1**	Ability to represent the time-invariant systems in state space form as well as analyze and realize the state models.							
	CO2	Ability to find whether the system is stabilizable, controllable, observable and detectable and Ability to design state feedback controller and state observers							
	CO3	Ability to design state feedback controller and state observers and Ability to classify singular points and construct phase trajectory using delta and isocline methods.							
	CO4	Use the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system.							
	CO5	Ability to describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.							

UNIT I	**STATE SPACE APPROACH**	**Periods** : **9**
Review of state model for systems – No uniqueness of state model - Role of Eigen values and Eigenvectors - State transition matrix and its properties – free and forced responses – State Diagrams - minimal realization – balanced realization.		**CO1**
UNIT II	**STATE FEEDBACK CONTROL AND STATE ESTIMATOR**	**Periods** : **9**
Controllability and observability – Stabilizability and Detectability - Kalman Decomposition - State Feedback – Pole placement technique – Full order and Reduced Order Observers		**CO2**
UNIT III	**NON-LINEAR SYSTEMS**	**Periods** : **9**
Types of Non-Linearity – Typical Examples – Singular Points - Phase plane analysis (analytical and graphical methods) – Limit cycles – Equivalent Linearization – Describing Function Analysis, Derivation of Describing Functions for different non-linear elements.		**CO3**
UNIT IV	**STABILITY OF NON-LINEAR SYSTEMS**	**Periods** : **9**
Stability concepts – Equilibrium points – BIBO and Asymptotic stability – Stability Analysis by DF method – Lyapunov Stability Criteria – Krasovskil's method – Variable Gradient Method – Popov's Stability Criterion – Circle Criterion		**CO4**
UNIT V	**NON-LINEAR SYSTEMS ANALYSIS**	**Periods** : **9**
Bifurcation Behavior of Single ODE Systems: - Motivation, Illustration of Bifurcation Behavior and Types of Bifurcations - Bifurcation Behavior of Two-State Systems: - Dimensional Bifurcations in the Phase-Plane, Limit Cycle Behavior and Hopf Bifurcation - Introduction to Chaos: The Lorenz Equations, Stability Analysis of the Lorenz Equations, Numerical Study of the Lorenz Equations, Chaos in Chemical Systems and Other Issues in Chaos		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. K.Ogata, "Modern Control Engineering", Prentice Hall, Fifth Edition, 2010.
2. M.Gopal, "Digital Control and State Variable Methods: Conventional and Intelligent Control Systems", Third Edition, Tata Mc-Graw Hill, 2009.
3. B.W.Bequette, "Process Control: Modeling, Design and Simulation", Prentice Hall International series in Physical and Chemical Engineering Sciences, 2003.
4. Steven E. LeBlanc, Donald R. Coughanowr, "Process Systems Analysis and Control", Third Edition, Chemical Engineering series, McGraw-Hill Higher Education, 2008

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	1	1	1	1	-	-	-	-	-	-	-	-	-	-
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CO3	2	2	1	2	2	-	-	-	-	-	-	-	-	-	-
CO4	2	2	1	2	2	-	-	-	-	-	-	-	-	-	-
CO5	2	3	1	2	2	-	-	-	-	-	-	-	-	-	-

Score: **3** – High; **2** – Medium; **1** – Low

Department: EIE		Programme: **M.Tech.(Instrumentation Engineering)**						
Semester:		Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	**T**	**P**		**CA**	**SE**	**TM**
EIZ02	**Advanced Image Processing**	3	-	-	3	40	60	100
Prerequisite								

Course Outcome	On completion of the course the Learner will be able to	
	CO1	Understand the basics of Image acquisition & basic mathematical tools
	CO2	Understand and apply simple enhancement techniques to images
	CO3	Understand and apply different segmentation techniques
	CO4	Apply different compression standards & identify different Descriptors
	CO5	Apply to projects based on machine vision and create simple applications

UNIT I	**DIGITAL IMAGE FUNDAMENTALS**	**Periods** : **9**	
Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels – Color image fundamentals – RGB, HSI models, Two-dimensional mathematical preliminaries, 2D transforms – DFT, DCT.			**CO1**
UNIT II	**IMAGE ENHANCEMENT**	**Periods** : **9**	
Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering, Frequency Domain: Introduction to Fourier Transform– Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters, Homomorphic filtering, Color image enhancement			**CO2**
UNIT III	**IMAGE SEGMENTATION**	**Periods** : **9**	
Edge detection, Edge linking via Hough transform – Thresholding – Region based segmentation – Region growing – Region splitting and merging – Morphological processing- erosion and dilation, Segmentation by morphological watersheds – basic concepts – Dam construction – Watershed segmentation algorithm			**CO3**
UNIT IV	**IMAGE COMPRESSION AND RECOGNITION**	**Periods** : **9**	
Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, JPEG standard, MPEG. Boundary representation, Boundary description, Fourier Descriptor, Regional Descriptors – Topological feature, Texture – Patterns and Pattern classes – Recognition based on matching.			**CO4**
UNIT V	**APPLICATIONS**	**Periods** : **9**	
Object Tracking – Video tracking – OCR recognition – Image Segmentation in Biomedical & Satellite Images – Machine Vision – Fingerprint recognition			**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Rafael C. Gonzales, Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education, 2010.
2. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition Tata Mc Graw Hill Pvt. Ltd., 2011.
3. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", First Edition, PHI Learning Pvt. Ltd., 2011.

CO – PO Mapping

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CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	2	3
CO5	3	3	3	3	3	2	2	-	-	-	-	2	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

Department: EIE		Programme: **M.Tech.(Instrumentation Engineering)**							
Semester:		Course Category Code:				Semester Exam Type: **TY**			
Course Code	Course Name	Periods / Week			Credit	Maximum Marks			
		L	**T**	**P**		**CA**	**SE**	**TM**	
EIZ03	**Virtual Instrumentation**	3	-	-	3	40	60	100	
Prerequisite									
Course Outcome	On completion of the course the Learner will be able to								
	CO1	Understand the basics of Virtual Instrumentation Programming							
	CO2	Understand and apply programming structures							
	CO3	Understand and apply different interfacing for data acquisition							
	CO4	Apply different Tools for Designing Control Systems							
	CO5	Apply different tools for designing Machine vision applications							

UNIT I	**VI PROGRAMMING BASICS**	**Periods : 9**
Evolutions of VI, advantages, block diagram and architecture of a virtual Instrument - Controls and indicators- Labels and Text –Shape, size and color- – Data type, Format, Precision and representation – Data types – Data flow Programming-Editing – Debugging and Running a Virtual Instrument – Concept of subVI.		**CO1**
UNIT II	**PROGRAMMING STRUCTURES**	**Periods : 9**
FOR Loops, WHILE Loops, CASE Structure, Formula nodes, Sequence structures- Attribute Modes Local and Global Variables Arrays and Clusters– Array Operations – Bundle – Bundle/Unbundle by name, graphs and charts – String and file I/O - Event Structures		**CO2**
UNIT III	**INTERFACE STANDARDS AND DAQ**	**Periods : 9**
DAQ hardware configuration, sampling methods and grounding techniques, analog I/O, digital I/O, counter/timer, DAQ software architecture, RS232, RS485, GPIB. Interface Buses: USB, Firewire Backplane buses: PCI, PCI-Express, PXI, PXI – Express; Communication protocol overview - Industrial Ethernet, CAN - MyRIO		**CO3**
UNIT IV	**CD TOOLBOX**	**Periods : 9**
Obtaining the Transfer Function (TF) & State Space (SS) Model of a given system - Conversion from TF to SS models - Obtaining the step response - Measurement of Time domain Parameters - Obtaining the Bode plot & pole zero map for a given system - Writing & reading models. Series & feedback connection of transfer function models – Case studies on development of HMI, SCADA		**CO4**
UNIT V	**IMAQ TOOLBOX**	**Periods : 9**
Image Acquisition – Image preprocessing – basic operation on Images - Image segmentation – Feature extraction – Machine Vision basics - Object Tracking – OCR – ANN & Deep Learning for machine vision applications		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Jovitha Jerome, —Virtual Instrumentation using LabVIEW‖, PHI Learning Pvt. Ltd., 2010.
2. Thomas Klinger, Image Processing with Labview and Imaq Vision (National Instruments), Virtual Instrumentation Series

1. Steve Mackay, Edwin Wright, John Park, and Deon Reynders, — Industrial Data Networks, Elsevier, 2004.
2. Gary Johnson and Richard Jennings —LabVIEW Graphical Programming, McGraw Hill Inc., Fourth Edition, 2006.
3. Sanjay Gupta and Joseph John, —Virtual Instrumentation using LabVIEW, Tata McGraw-Hill Inc., 2005.
4. William Buchanan, —Computer Buses Design and Application, CRC Press, 2000.

Clyde F Coombs, —Electronic Instruments Handbook, McGraw Hill Inc., Third Edition, 1999.

CO – PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	-	-	-	-	-	-	-	2	2	2
CO2	3	3	3	2	2	-	-	-	-	-	-	-	2	2	2
CO3	3	3	3	3	3	1	3	-	-	-	-	-	3	3	3
CO4	3	3	3	3	3	2	3	-	-	-	-	-	3	3	3
CO5	3	3	3	3	3	2	3	-	-	-	-	-	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

<table>
<tr><td colspan="2">Department: Electronics and Instrumentation Engineering</td><td colspan="8">Programme: M.Tech. Instrumentation Engineering</td></tr>
<tr><td colspan="2">Semester: I</td><td colspan="4">Course Category Code:</td><td colspan="4">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EIZ04</td><td>Data Analytics for Instrumentation Engineers</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">Engineering mathematics</td></tr>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td colspan="7">Ability to understand the basics of data analytics and Python programming.</td></tr>
<tr><td>CO2</td><td colspan="7">Ability to understand the basics of Probability and Probability distributions.</td></tr>
<tr><td>CO3</td><td colspan="7">Ability to understand Hypothesis testing, ANOVA and Regression</td></tr>
<tr><td>CO4</td><td colspan="7">Ability to understand model building , Linear Regression Model Vs Logistic Regression Model.</td></tr>
<tr><td>CO5</td><td colspan="7">Ability to use Clusters, analysis of clusters and apply the data analytics principle for Instrumentation.</td></tr>
</table>

UNIT I	**Introduction to Data Analytics and Python**	**Periods : 9**
Introduction to data analytics and Python fundamentals-Conditional Statements, Looping, Control Statements, String Manipulation, Lists, Tuple, Dictionaries, Functions, Modules,I nput-Output, Exception Handling.		**CO1**
UNIT II	**Introduction to Probability**	**Periods : 9**
Central Tendency and Dispersion,Introduction to probability, Probability distributions,Distribution of Sample-Means, population, and variance,Confidence interval estimation.		**CO2**
UNIT III	**Hypothesis testing**	**Periods : 9**
Hypothesis Testing ,Errors in Hypothesis Testing, Two sample test, Introduction to ANOVA, Two way ANOVA, linear regression, Estimation, Prediction of Regression Model Residual Analysis,Multiple Regression Model,Categorical variable regression.		**CO3**
UNIT IV	**Linear and multipleregression**	**Periods : 9**
Maximum Likelihood Estimation,Logistic regression, Linear Regression Model Vs Logistic Regression Model, Confusion matrix and ROC-Performance of Logistic Model,Regression Analysis Model Building.		**CO4**
UNIT V	**Cluster Analysis**	**Periods : 9**
Chi - Square Test of Independence,Chi-Square Goodness of Fit Test,Introduction to Cluster Analysis,K-Means Clustering ,Hierarchical method of clustering,Classification and Regression Trees,Measures of attribute selection,Attribute selection Measures in CART,Classification and Regression Trees.Case studies of Data Analytics applicable to Instrumentation.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Anil Maheshwari, "Data Analytics" 1 July 2017
2. Bharti Motwani, "Data Analytics using Python",Wiley,25 June 2020
3. Hastie, Trevor, et al.;The elements of statistical learning.Vol.2. No. 1. New York:Springer, 2009.
4. Montgomery, Douglas C., and George C. Runger.;Applied statistics and probability for engineers. John Wiley & Sons,2010

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	3	3	3	-	-	-					3	3	3
CO2	3	3	3	3	3	-	-	3					3	3	3
CO3	3	3	3	3	3	-	-	1					3	3	3
CO4	3	3	2	3	3	-	-	1					3	3	3
CO5	3	1	2	3	3	-	-	1					3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

<table>
<tr><td colspan="2">Department: EIE</td><td colspan="4">Programme: M.Tech.(Instrumentation Engineering)</td><td colspan="3"></td></tr>
<tr><td colspan="2">Semester:</td><td colspan="4">Course Category Code:</td><td colspan="3">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EIZ05</td><td>Advanced Biomedical Instrumentation</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td rowspan="6">Course Outcome</td><td colspan="8">On completion of the course the Learner will be able to</td></tr>
<tr><td>CO1</td><td colspan="7">Understand the basics of Biomedical Measurements</td></tr>
<tr><td>CO2</td><td colspan="7">Understand and perform modelling & simulation of Bio systems</td></tr>
<tr><td>CO3</td><td colspan="7">Understand the origin of Different Bio signals and Acquisition</td></tr>
<tr><td>CO4</td><td colspan="7">Understand the instruments for Diagnosis & Monitoring</td></tr>
<tr><td>CO5</td><td colspan="7">Understand the importance of Implants & simple microsystems</td></tr>
<tr><td>UNIT I</td><td colspan="5">INTRODUCTION TO BIOMEDICAL MEASUREMENTS</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="8">Physiological systems and measurable variables- Nature and complexities of biomedical measurements- Medical equipment standards- organization, classification and regulation- Biocompatibility - Human and Equipment safety – Physiological effects of electricity, Micro and macro shocks, thermal effects</td><td>CO1</td></tr>
<tr><td>UNIT II</td><td colspan="5">ADVANCES IN MODELING AND SIMULATIONS IN BIOMEDICAL INSTRUMENTATION</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="8">Modeling and simulation in Biomedical instrumentation – Difference in modeling engineering systems and physiological systems – Model based analysis of Action Potentials - cardiac output – respiratory mechanism - Blood glucose regulation and neuromuscular function</td><td>CO2</td></tr>
<tr><td>UNIT III</td><td colspan="5">BIOMEDICAL SIGNALS AND THEIR ACQUISITIONS</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="8">Types and Classification of biological signals– Noise and artifacts and their management - Biopotential electrodes- types and characteristics - Origin, recording schemes and analysis of biomedical signals with typical examples of Electrocardiography(ECG), Electroencephalograhy (EEG), and Electromyography (EMG)– Processing and transformation of signals-applications of wavelet transforms in signal compression and denoising</td><td>CO3</td></tr>
<tr><td>UNIT IV</td><td colspan="5">INSTRUMENTATION FOR DIAGNOSIS AND MONITORING</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="8">Advanced medical imaging techniques and modalities -Instrumentation and applications in monitoring and diagnosis- Computed tomography, Magnetic Resonance Imaging and ultrasound- Algorithms and applications of artificial intelligence in medical image analysis and diagnosis-Telemedicine and its applications in telemonitoring</td><td>CO4</td></tr>
<tr><td>UNIT V</td><td colspan="5">BIOMEDICAL IMPLANTS AND MICROSYSTEMS</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="8">Implantable medical devices: artificial valves, vascular grafts and artificial joints-cochlear implants - cardiac pacemakers – Microfabriation technologies for biomedical Microsystems- microsensors for clinical applications – biomedical microfluid systems</td><td>CO5</td></tr>
<tr><td colspan="2">Lecture Periods: 45</td><td colspan="2">Tutorial Periods: -</td><td colspan="2">Practical Periods: -</td><td colspan="3">Total Periods: 45</td></tr>
<tr><td colspan="9"><u>Reference Books</u></td></tr>
</table>

1. R. Ananda Natarajan, Biomedical Instrumentation, PHI Publications, 2011
2. John G.Webster (editor), Bioinstrumentation, John Wiley & Sons, 2004.
3. Shayne Cox Gad, Safety Evaluation of Medical Devices, Marcel Deckle Inc, 2002.
4. Michael C. K. Khoo, Physiological Control Systems- Analysis Simulation and Estimation, 2001. & John G.Webster (editor), Medical Instrumentation Application and design, John Wiley Sons, 2005.
5. Cromwell l., Biomedical Instrumentation and Measurements, Prentice Hall of India, 1995.
6. RangarajM.Rangayan, Biomedical signal analysis, John Wiley & Sons (ASIA) Pvt. Ltd.,
7. Kayvannajarian and Robert splinter, Biomedical Signal and Image Processing, CRC Press, 2005.
8. John M.Semmlow, Biosignal and Bio medical Image processing, CRC Press, 2004.
9. Joseph J. Carr and John M Brown, Introduction to Biomedical Equipment Technology, Pearson Education, 2004

CO – PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	3	3	3	1	3	-	-	-	-	-	3	3	3
CO2	3	3	3	3	3	2	3	-	-	-	-	-	3	3	3
CO3	3	3	3	3	3	2	3	-	-	-	-	-	3	3	3
CO4	3	3	3	3	3	2	3	-	-	-	-	-	3	3	3
CO5	3	3	3	3	3	2	3	-	-	-	-	-	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

<table>
<tr><td colspan="3">Department: Electronics and Instrumentation Engineering</td><td colspan="8">Programme: M.Tech. Instrumentation Engineering</td></tr>
<tr><td colspan="3">Semester:</td><td colspan="5">Course Category Code:</td><td colspan="3">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td colspan="2" rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="4">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td colspan="2">SE</td><td>TM</td></tr>
<tr><td>EIZ06</td><td colspan="2">Artificial Intelligence and Deep Learning</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td colspan="2">60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="10">know the basics of VLSI fabrication</td></tr>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td colspan="9">To know the basics of artificial intelligence</td></tr>
<tr><td>CO2</td><td colspan="9">Knowledgeable about basic concepts of knowledge and reasoning</td></tr>
<tr><td>CO3</td><td colspan="9">Conceptual understanding of Learning and types</td></tr>
<tr><td>CO4</td><td colspan="9">Understanding the concepts of Deep Learning</td></tr>
<tr><td>CO5</td><td colspan="9">Able to understand the basics of optimization techniques</td></tr>
<tr><td>UNIT I</td><td colspan="6">Artificial Intelligence</td><td colspan="4">Periods : 9</td></tr>
<tr><td colspan="10">Introduction: What is AI? Foundations of AI, History of AI, Agents and environments, The nature of the Environment, Problem solving Agents, Problem Formulation, Search Strategies</td><td>CO1</td></tr>
<tr><td>UNIT II</td><td colspan="6">Knowledge and Reasoning:</td><td colspan="4">Periods : 9</td></tr>
<tr><td colspan="10">Knowledge-based Agents, Representation, Reasoning and Logic, Prepositional logic, First-order logic, Using First-order logic, Inference in First-order logic, forward and Backward Chaining</td><td>CO2</td></tr>
<tr><td>UNIT III</td><td colspan="6">Learning</td><td colspan="4">Periods : 9</td></tr>
<tr><td colspan="10">Learning: Learning from observations, Forms of Learning, Inductive Learning, Learning decision trees, why learning works, Learning in Neural and Belief networks</td><td>CO3</td></tr>
<tr><td>UNIT IV</td><td colspan="6">Deep Learning</td><td colspan="4">Periods : 9</td></tr>
<tr><td colspan="10">Introduction to Deep Learning, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss and case study examples</td><td>CO4</td></tr>
<tr><td>UNIT V</td><td colspan="6">Optimization</td><td colspan="4">Periods : 9</td></tr>
<tr><td colspan="10">Optimization Techniques, Gradient Descent, Batch Optimization, Effective training in Deep Net- early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization and case study examples</td><td>CO5</td></tr>
<tr><td colspan="2">Lecture Periods: 45</td><td colspan="2">Tutorial Periods: -</td><td colspan="3">Practical Periods: -</td><td colspan="4">Total Periods: 45</td></tr>
<tr><td colspan="11"><u>Reference Books</u></td></tr>
<tr><td colspan="11">1. Stuart Russell, Peter Norvig: “Artificial Intelligence: A Modern Approach”,2nd Edition, Pearson Education, 2007
2. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.
3. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
4. Artificial Intelligence , 2nd Edition, E.Rich and K.Knight (TMH)
5. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
6. Artificial Intelligence and Expert Systems – Patterson PHI
7. Golub, G.,H., and Van Loan,C.,F., Matrix Computations, JHU Press,2013.
8. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004</td></tr>
</table>

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	1	1	1	1	2	1	1	-	-	-	1	3	3	2
CO2	2	1	1	1	1	1	-	1	-	-	-	1	3	2	2
CO3	2	2	1	2	2	1	-	1	-	-	-	1	2	3	2
CO4	2	2	1	2	2	1	-	1	-	-	-	1	2	3	2
CO5	2	3	1	2	2	1	-	1	1	-	-	1	2	3	2

Score: **3** – High; **2** – Medium; **1** – Low

Department: Electronics and Instrumentation Engineering		Programme: **M.Tech. Instrumentation Engineering**						
Semester:		Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	**T**	**P**		**CA**	**SE**	**TM**
EIZ07	**INDUSTRIAL DRIVES AND CONTROL**	4	-	-	4	40	60	100
Prerequisite								

Course Objectives	**CO1**	To give an overview on fundamental aspects of motor-load systems and basic characteristics of dc and ac drives.
	CO2	To introduce various modeling methods of dc and ac drives
	CO3	To give detailed knowledge on operation, analysis and control of converter and chopper driven dc drives
	CO4	To give exposure to principle, techniques of conventional control of ac drives
	CO5	To introduce advanced control strategies of ac drives and latest developments in the field of control of electric drives.

UNIT I	**INTRODUCTION TO ELECTRIC DRIVES**	**Periods** : **9**	
Motor-Load system–Dynamics, load torque, steady state stability, Multi quadrant operations of drives. DC motors- speed reversal, speed control and breaking techniques, Characteristics of Induction motor and Synchronous motors-Dynamic and regenerative braking ac drives.			**CO1**
UNIT II	**MODELING OF DC AND AC MACHINES**	**Periods** : **9**	
Circuit model of Electric Machines-Transfer function and State space models of series and separately excited DC motor-AC Machines –Dynamic modeling –linear transformations equations in stator, rotor and synchronously rotating reference frames-flux linkage equations- Dynamic state space model-modeling of Synchronous motor			**CO2**
UNIT III	**CONTROL OF DC DRIVES**	**Periods** : **9**	
Analysis of series and separately excited DC motor with single phase and Three phase converters operating in different modes and configurations- Analysis of series and separately excited DC motor fed from different choppers,-two quadrant and four quadrant operation-Closed loop control of dc drives-Design of controllers			**CO3**
UNIT IV	**CONTROL OF AC DRIVES**	**Periods** : **9**	
Operation of induction motor with non-sinusoidal supply waveforms, Variable frequency operation of 3-phase inductions motors, constant flux operation, current fed operations, Constant torque operations, Static rotor resistance control and slip power recovery scheme –Synchronous motor control, control of stepped motors, Parameter sensitivity of ac drives.			**CO4**
UNIT V	**ADVANCED CONTROL OF AC DRIVES**	**Periods** : **9**	
Principles of vector control –Direct and indirect vector control of induction motor –DTC- sensor less vector control-speed estimation methods-Applications of Fuzzy logic and Artificial Neural Network for the control of AC drives.			**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Course Outcome	**CO1**	Get a thorough understanding of motor-load system dynamics and stability, modern drive system objectives and fundamentals of dc and ac motors
	CO2	Will have the ability to model both dc and ac motors in various conventional methods
	CO3	Confidently design and analyze both the converter and chopper driven dc drives
	CO4	Ability to understand the conventional control techniques of ac drives and will have the ability to design and analyze such system
	CO5	Get a detailed knowledge on advanced high performance control strategies for ac drives and emerging technologies in electric drives. And Will have a comprehensive exposure to emerging technologies like AI in the field of electric drives

Reference Books

1 G.K.Dubey, “Power Semiconductor Controlled Drives,” Prentice Hall International, New Jersey, 1989.
2 Paul .C.Krause, Oleg wasynczuk and Scott D.Sudhoff, “Analysis of Electric Machinery and Drive Systems”, 2ndedition , Wiley-IEEE Press, 2013.
3 Bimal K Bose, “Modern Power electronics and AC Drives”, Pearson education Asia, 2002.
4 R .Krishnan, “Electrical Motor

MAPPING INDUSTRIAL DRIVES AND CONTROL OUTCOMES WITH POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	2	2	2		1	-	2	2	3
CO2			1	3			2		3
CO3		1	2	3	3			1	3
CO4		2	1	3	2		2	1	3
CO5		1	2	3	1		2		3

Department: Electronics and Instrumentation Engineering		Programme: **M.Tech. Instrumentation Engineering**						
Semester:		Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	**T**	**P**		**CA**	**SE**	**TM**
EIZ08	**VLSI System Design**	3	-	-	3	40	60	100
Prerequisite	Digital Electronics							

Course Outcome	**CO1**	Ability to understand MOS transistor, CMOS technology and logic implementation using CMOS.
	CO2	Ability to understand stick diagram and design CMOS circuits.
	CO3	Ability to understand the HDL, working knowledge of VHDL
	CO4	Ability to design complex digital systems using component instantiation
	CO5	Ability to use FPGA and CPLD – synthesis of VLSI systems - floor planning, placement and routing.

UNIT I	**BASIC DEVICE CHARACTERISTICS**	**Periods : 9**
Introduction to MOS technology- Transistor Characteristic under Static and Dynamic Conditions - enhancement and depletion mode of operation - NMOS, PMOS - Quality metrics of a digital design: Cost, Functionality, Robustness, Power, and Delay, Stick diagram and Layout, Wire delay models.		**CO1**
UNIT II	**CMOS IMPLEMENTATION**	**Periods : 9**
CMOS design rules and layout, CMOS transmission gates, inverters, CMOS logic gates – CMOS power dissipation- Switching threshold and noise margin concepts and their evaluation, Dynamic behavior, Power Consumption. Implementation of basic combinational circuits using CMOS – IC fabrication process.		**CO2**
UNIT III	**INTRODUCTIONTO VHDL**	**Periods : 9**
VHDL basics - VHDL levels of abstraction – Structural, Behavioral and dataflow modes of implementation- The VHDL design flow - VHDL design entities - Entity declarations - Architectures – Concurrent signal assignments - Signal assignments with delays – Signal and variable assignments - Sequential statements - VHDL processes - Processes sensitivity lists Conditional statements – loops - selective signal assignments.		**CO3**
UNIT IV	**SYSTEM IMPLEMENTATION USING VHDL**	**Periods : 9**
Component declarations - Component instantiation - Named port mapping – Positional port mapping – Packages - Package declaration - Package body. Test Bench Development in VHDL- Simple Test Benches – Implementation of combinational and sequential circuits in VHDL.		**CO4**
UNIT V	**FPGAs AND CPLDs**	**Periods : 9**
Introduction - FPGA Architecture – FPGA Configuration Types – MASK Programmed FPGAs. Introduction to CPLDs Comparison of FPGAs and CPLDs from Xilinx, Altera and Actel - Introduction to ASIC – FPGA based system design - High level synthesis - overview for floor planning,placement and routing.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Ajay Kumar Singh, Digital VLSI Design , PHI Learning Pvt. Ltd, 2010.
2. J. Bhasker ,VHDL Primer, Prentice Hall, 2006.
3. Chip Design for Submicron VLSI: CMOS Layout & Simulation, - John P. Uyemura, Thomson Learning.
4. Introduction to VLSI Circuits and Systems - John .P. Uyemura, JohnWiley,

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	2	3	1	1	-	-	-	1	-	2	1	1	3	1
CO2	3	3	3	1	3	-	-	3	2	-	2	3	2	1	1
CO3	2	2	3	1	3	-	-	1	3	-	2	3	3	3	1
CO4	2	1	2	1	3	-	-	1	3	-	1	2	3	1	1
CO5	2	1	2	1	3	-	-	1	3	-	1	1	3	3	1

Score: **3** – High; **2** – Medium; **1** – Low

Department: EIE		Programme: **M.Tech.(Instrumentation Engineering)**						
Semester:		Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	**T**	**P**		**CA**	**SE**	**TM**
EIZ09	**INDUSTRIAL IOT**	3	1	-	4	40	60	100
Prerequisite	-							

Course Outcome	On completion of the course the Learner will be able to
CO1	Understand architecture of Industrial Internet of Things
CO2	Design IoT perspective by thinking and building solutions using sensors
CO3	Understand various IoT Layers and their relative importance
CO4	Realize the importance of Data Analytics and Security in IIoT
CO5	Understand, design and create the real life IoT applications using off the shelf hardware and software

UNIT I	**Architectures of IIOT**	**Periods :12**
Overview of IOT components ;Various Architectures of IOT and IIOT, Advantages & disadvantages, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT -Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking		**CO1**
UNIT II	**Sensor and Interfacing**	**Periods :12**
Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT , Various types of sensors , Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators. Hardwire the sensors with different protocols such as HART, MODBUS-Serial & Parallel, Ethernet, BACNet , Current, M2M etc		**CO2**
UNIT III	**Protocols and Cloud**	**Periods :12**
Need of protocols; Types of Protocols, Wi-Fi, Wi-Fi direct, Zigbee, Z wave, Bacnet, BLE, Modbus, SPI , I2C, IIOT protocols –COAP, MQTT,6lowpan, lwm2m, AMPQ IIOT cloud platforms : Overview of cots cloud platforms, predix, thing works, azure etc. Data analytics, cloud services, Business models: Saas, Paas, Iaas.		**CO3**
UNIT IV	**IIOT Analytics and security**	**Periods :12**
IOT Analytics : Role of Analytics in IIOT, Data visualization Techniques, Introduction to R Programming, Statistical Methods. Big Data Analytics and Software Defined Networks, Machine Learning and Data Science, Julia Programming, Data Management with Hadoop. Security and Fog Computing - Cloud Computing in IIoT, Fog Computing in IIoT, Security in IIoT		**CO4**
UNIT V	**Case Study**	**Periods :12**
Industrial IoT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies : Milk Processing and Packaging Industries, Manufacturing Industries		**CO5**

Lecture Periods: 60	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 60**
Reference Books			

1. Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress), 2017
2. "Industrial Internet of Things: Cyber manufacturing Systems" by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer), 2017
3. Hands-On Industrial Internet of Things: Create a powerful Industrial IoT by Giacomo Veneri, Antonio Capasso, Packt, 2018.
4. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications .
5. Bernd Scholz-Reiter, Florian 2. Michahelles, "Architecting the Internet of Things", ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2, Springer
6. HakimaChaouchi, " The Internet of Things Connecting Objects to the Web" ISBN : 978-1- 84821-140-7, Willy Publications
7. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2 nd Edition, Willy Publications .
8. Internet of Things- From Research and Innovation to Market Deployment; By Ovidiu& Peter; River Publishers Series, ISBN: 978-87-93102-94-1 (Hard copy) 978-87-93102-95-8 (Ebook) ,2014

CO – PO -PSO Mapping for Industrial IOT

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	2	-	-	-	-	-	1	3	2	3
CO2	3	3	3	3	3	2	-	-	-	-	-	1	3	2	3
CO3	3	3	3	3	3	2	-	-	-	-	-	1	3	2	3
CO4	3	3	3	3	3	2	1	-	-	-	-	1	3	3	3
CO5	3	3	3	3	3	2	2	1	1	-	2	2	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

Department: EIE			Programme: **M.Tech.(Instrumentation Engineering)**						
Semester:			Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	**T**	**P**		**CA**	**SE**	**TM**
EIZ10	**System Identification**		3	1	-	4	40	60	100
Prerequisite	Engineering Mathematics and Control Systems								
Course Outcome	On completion of the course the Learner will be able to								
	CO1	have an exposure of various System and their models.							
	CO2	have an exposure on Parameter Estimation Methods							
	CO3	have an exposure on Recursive Identification Methods							
	CO4	have knowledge of system identification concepts using closed loop.							
	CO5	solve estimation problems in Instrumentation and control							

UNIT I	**Introduction to system identification**	**Periods :12**	
Dynamic systems, Models for Linear Time-invariant Systems, time varying systems and nonlinear systems, The system identification procedure, Non-parametric methods- transient analysis, Frequency analysis, correlation analysis and spectral analysis.			**CO1**
UNIT II	**Parameter Estimation Methods**	**PERIODS :12**	
Least square estimation – best linear unbiased estimation under linear constraints – updating the parameter estimates for linear regression models – prediction error methods: description of prediction methods – optimal prediction – relation between prediction error methods and other identification methods – theoretical analysis - Instrumental variable methods: Description of instrumental variable methods – Input signal design for identification			**CO2**
UNIT III	**Recursive Identification Methods**	**PERIODS :12**	
The recursive least square method – the recursive instrumental variable methods- the recursive prediction error methods – Maximum likelihood			**CO3**
UNIT IV	**Closed- Loop Identification**	**PERIODS :12**	
Identification of systems operating in closed loop: Identifiability considerations – direct identification – indirect identification – joint input / output identification - Subspace methods for estimating state space models.			**CO4**
UNIT V	**Practical Aspects of Identification**	**PERIODS :12**	
Practical aspects: experimental conditions – drifts and de-trending – outliers and missing data – pre-filtering - robustness – Model validation and Model structure determination-case studies – Introduction to Nonlinear System Identification- Introduction to Control relevant System Identification			**CO5**

Lecture Periods: 60	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 60**

<u>Reference Books</u>

1. Soderstorm T and Peter Stoica, System Identification, Prentice Hall International, 1989.
2. Ljung L, System Identification: Theory for the user, Prentice Hall, Englewood Cliffs, 1987.
3. E. Ikonen and K. Najim, “ Advanced Process Identification and Control”, Marcel Dekker, Inc. Newyork,2002.

<u>CO – PO -PSO Mapping for System Identification</u>

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	3	2	2	-	-	-	-	-	-	-	3	2	3
CO2	3	3	3	3	3	1	-	-	-	-	-	-	3	2	3
CO3	3	3	3	3	3	1	-	-	-	-	-	-	3	2	3
CO4	3	3	3	3	3	1	-	-	-	-	-	-	3	2	3
CO5	3	3	3	3	3	2	1	-	-	-	1	2	3	3	3

<u>Score</u>: **3** – High; **2** – Medium; **1** – Low

Department: ELECTRONICS AND INSTRUMENTATTION ENGINEERING		Programme: **M.Tech. Instrumentation Engineering**						
Semester:		Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	**T**	**P**		**CA**	**SE**	**TM**
EIZ11	**ROBOTICS AND AUTOMATION**	3	-	-	3	40	60	100
Prerequisite								

COURSE OBJECTIVES	**CO1**	To know the basic terminologies, classification of robot and configurations of serial manipulator
	CO2	To understand the mechanical design and kinematics of serial manipulator
	CO3	To learn the robot programing and safety consideration of industrial manipulator
	CO4	To understand the concepts and stabilization of legged and wheeled mobile robots
	CO5	To demonstrate the robots in various applications

UNIT I	**INTRODUCTION TO SERIAL MANIPULATORS**	**Periods** : **9**
Types of Industrial Robots, Definitions – Classifications Based on Work Envelope – GenerationsConfigurations and Control Loops - Co-Ordinate System – Need for Robot – Basic Parts andFunctions – Specifications – Robotic Sensor - Position and Proximity's Sensing – Tactile Sensing – Sensing Joint Forces.of Robot Motion – Direct and Indirect Kinematics Homogeneous Transformations – D-HTransformation – Drive Systems – End Effectors – Types, Selection, Classification and Design ofGrippers – Gripper Force Analysis.		**CO1**
UNIT II	**MECHANICAL DESIGN OF ROBOT SYSTEM**	**Periods** : **9**
Robot Motion – Linkages and Joints – Mechanism – Method for Location and Orientation of Objects Kinematics		**CO2**
UNIT III	**ROBOT PROGRAMMING & ROBOTIC WORK CELLS**	**Periods** : **9**
Types of Programming – Teach Pendant Programming – Basic Concepts in AI Techniques – Concept of Knowledge Representations – Expert System and its Components Robotic Cell Layouts – Inter Locks.		**CO3**
UNIT IV	**MOBILE ROBOTICS**	**Periods** : **9**
Wheeled Robot and Legged Robot – Architecture - Configurations and Stability - Design Space and Mobility Issues - Teleportation and Control – Localization – Navigation – AGV		**CO4**
UNIT V	**APPLICATIONS OF ROBOTS**	**Periods** : **9**
Robotic Surgery - Manufacturing Industries - Material Handling, Assembly, Inspection - Space – Underwater – Nuclear industry – Humanoid Robots		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Course Outcome	**CO1**	Classify the various configurations of serial manipulators.
	CO2	Develop the kinematics solution of serial manipulator
	CO3	Find the differences of robot programing languages and safety consideration of industrial manipulator
	CO4	Develop the legged and wheeled mobile robots.
	CO5	Demonstrate the robots in various applications.

Reference Books

1. Fu.K.S, GonzalacR.C, Lee C.S.G, "Robotics Control, Sensing, Vision and Intelligence", Mc- Graw Hill book co 2011.
2. Groover.M.P. "Industrial Robotics, Technology, Programming and Application", Mc-Graw Hill book and co. 2012
3. John J Craig, "Introduction to Robotics", Pearson, 2005.
4. Saeed B.Niku, "Introduction to Robotics, Analyses, Systems, Applications", Prentice Hall Pvt Ltd., 2005.
5. YoramKoren, "Robotics", McGraw Hill 2006.

MAPPING ROBOTICS AND AUTOMATIONOUTCOMES WITH POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3					-	3	2	3
CO2		2	3	3			3	2	3
CO3	2	2	3	3	3	1	3	2	3
CO4	2	3	3	3	3	1	3	2	3
CO5	3	1	3	3	3	2	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

<table>
<tr><td colspan="2">Department: ELECTRONICS AND INSTRUMENTATTION ENGINEERING</td><td colspan="8">Programme: M.Tech. Instrumentation Engineering</td></tr>
<tr><td colspan="2">Semester:</td><td colspan="4">Course Category Code:</td><td colspan="4">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EIZ12</td><td>ROBUST CONTROL</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8"></td></tr>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td colspan="7">Know about norms, random spaces and robustness measures</td></tr>
<tr><td>CO2</td><td colspan="7">Obtain Knowledge on H2 optimal control and estimation techniques</td></tr>
<tr><td>CO3</td><td colspan="7">Ability to use H-infinity optimal control techniques for designing robust control systems</td></tr>
<tr><td>CO4</td><td colspan="7">Learn about LMI approach of H-infinity control</td></tr>
<tr><td>CO5</td><td colspan="7">Obtain knowledge on synthesis techniques for robust controllers</td></tr>
<tr><td>UNIT I</td><td colspan="6">INTRODUCTION TO ROBUST CONTROL</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="8">Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – vector Random spaces- Specification for feedback systems – Co-prime factorization and Inner functions – structured and unstructured uncertainty- robustness</td><td>CO1</td></tr>
<tr><td>UNIT II</td><td colspan="6">H2 OPTIMAL CONTROL</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="8">Linear Quadratic Controllers – Characterization of H2 optimal controllers – H2 optimal estimation- KalmanBucy Filter – LQG Controller</td><td>CO2</td></tr>
<tr><td>UNIT III</td><td colspan="6">H-INFINITY OPTIMAL CONTROL-RICCATI</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="8">APPROACH Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – H-infinity estimation</td><td>CO3</td></tr>
<tr><td>UNIT IV</td><td colspan="6">H-INFINITY OPTIMAL CONTROL- LMI APPROACH</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="8">Formulation – Characterization of H-infinity sub-optimal controllers by means of LMI Approach – Properties of H-infinity sub-optimal controllers – H-infinity synthesis with pole-placement constraints</td><td>CO4</td></tr>
<tr><td>UNIT V</td><td colspan="6">SYNTHESIS OF ROBUST CONTROLLERS & CASE STUDIES</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="8">Synthesis of Robust Controllers – Small Gain Theorem – D-K –iteration- Control of Inverted Pendulum- Control of CSTR – Control of Aircraft – Robust Control of Second-order Plant, Robust Control of Distillation Column</td><td>CO5</td></tr>
<tr><td colspan="2">Lecture Periods: 45</td><td colspan="2">Tutorial Periods: -</td><td colspan="3">Practical Periods: -</td><td colspan="2">Total Periods: 45</td></tr>
<tr><td colspan="9"><u>Reference Books</u></td></tr>
<tr><td colspan="9">1. U. Mackenroth “Robust Control Systems: Theory and Case Studies”,Springer International Edition, 2010.
2. J. B. Burl, “ Linear optimal control H2 and H-infinity methods”, Addison W Wesley, 1998
3. D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances In Design and Control”, Society for Industrial and Applied Mathematics, 2007.
4. I.R. Petersen, V.A. Ugrinovskii and A. V. Savkin, “Robust Control Design using H- infinity Methods”, Springer, 2000.
5. M. J. Grimble, “Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems”, John Wiley and Sons Ltd., Publication, 2006.</td></tr>
</table>

<u>CO – PO Mapping</u>

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	2	2	1	2	-	-	-	-	-	-	-	-	-	-
CO2	2	2	2	1	2	-	-	-	-	-	-	-	-	-	-
CO3	2	2	2	2	3	-	-	-	-	-	-	-	-	-	-
CO4	2	3	3	2	3	-	-	-	-	-	-	-	-	-	-
CO5	2	3	3	2	3	-	-	-	-	-	-	-	-	-	-

<u>Score</u>: **3** – High; **2** – Medium; **1** – Low

<table>
<tr><td colspan="2">Department: Electronics and Instrumentation Engineering</td><td colspan="8">Programme: M.Tech. Instrumentation Engineering</td></tr>
<tr><td colspan="2">Semester:</td><td colspan="4">Course Category Code:</td><td colspan="4">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EIZ13</td><td>Thermal Power Plant Instrumentation</td><td>4</td><td>-</td><td>-</td><td>4</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">Control Systems</td></tr>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td colspan="7">Students understands various power generation processes and have knowledge on boilers in thermal power plants.</td></tr>
<tr><td>CO2</td><td colspan="7">Students knows the operation and measuring methods of various no-electrical parameters important for the thermal power plants, like flow rate, temperate, pressure etc, and benefits safety interlocks.</td></tr>
<tr><td>CO3</td><td colspan="7">Students can able to understand types measurement systems and control strategies for turbines.</td></tr>
<tr><td>CO4</td><td colspan="7">Students can able understand Mathematical modelling and different Advanced control strategies</td></tr>
<tr><td>CO5</td><td colspan="7">Ability to describe performance evaluation of boiler and economic operation of plant</td></tr>
<tr><td>UNIT I</td><td colspan="5">Basics of Thermal Power Plant</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="7">Process of power generation in coal – fired and oil-fired thermal power plants- Types of Boilers-Combustion process – Super heater – Turbine – Importance of Instrumentation in thermal power plants.</td><td colspan="2">CO1</td></tr>
<tr><td>UNIT II</td><td colspan="5">Boiler Control</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="7">Combustion control: Air-fuel ratio control-furnace draft control –Drum level control –Steam temperature Control– DCS in power plant – Interlocks in Boiler Operation.</td><td colspan="2">CO2</td></tr>
<tr><td>UNIT III</td><td colspan="5">Turbine Monitoring and Control</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="7">Measurement of speed, vibration, shell temperature of steam turbine – Steam pressure Control – Speed control of turbine – Alternator- Monitoring voltage and frequency – Operation of several units in parallel- Synchronization</td><td colspan="2">CO3</td></tr>
<tr><td>UNIT IV</td><td colspan="5">Boiler Modelling and Advanced Control</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="7">Development of mathematical model of combustion chamber, boiler drum and super heater – ANN based model – Model predictive control of super heater – control of drum level using AI techniques.</td><td colspan="2">CO4</td></tr>
<tr><td>UNIT V</td><td colspan="5">Optimization of Thermal Power Plant Operation</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="7">Determination of Boiler efficiency – Heat losses in Boiler – Effect of excess air – Optimizing total air supply- Combustible material in ash- Reduction of turbine losses-Choice of optimal plant parameters-Economics of operation.</td><td colspan="2">CO5</td></tr>
<tr><td colspan="2">Lecture Periods: 45</td><td colspan="2">Tutorial Periods: -</td><td colspan="2">Practical Periods: -</td><td colspan="3">Total Periods: 45</td></tr>
<tr><td colspan="9"><u>Reference Books</u></td></tr>
<tr><td colspan="9">1. David Lindsley, “Power Plant Control & Instrumentation”, IEE Publications, London, UK(2001)
2. Sam G.Dukelow, The control of Boilers, Instrument Society of America, 1991.
3. S.M.Elonko and A.L.Kohal –Standard Boiler Operations, McGraw Hill, New Delhi, 1994.
4. R.K.Jain -Mechanical and Industrial Measurements, Khanna publishers, New Delhi, 1995.
5. A.K.Mahalanbias-“Power System Instrumentation”-Tata McGraw Hill.</td></tr>
</table>

<u>CO – PO Mapping</u>

Department: Electronics and Instrumentation Engineering	Programme: **M.Tech. Instrumentation Engineering**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	2	2	-	2	2	-	-	-	-	-	-	-	-	-
CO2	3	3	3	-	3	3	2	2	-	-	-	-	-	-	-
CO3	3	3	3	2	3	2	2	2	-	2	2	2	-	-	-
CO4	3	3	3	2	3	2	2	-	-	2	2	2	-	-	-
CO5	3	3	3	2	3	2	-	-	-	2	2	-	-	-	-

Score: **3** – High; **2** – Medium; **1** – Low

<table>
<tr><td colspan="3">Semester:</td><td colspan="4">Course Category Code:</td><td colspan="3">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EIZ14</td><td colspan="2">Micro-Electro Mechanical Systems</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="9">basics of VLSI fabrication</td></tr>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td colspan="8">Understand the concepts of micro systems.</td></tr>
<tr><td>CO2</td><td colspan="8">Knowledgeable about materials and fabrication methods</td></tr>
<tr><td>CO3</td><td colspan="8">Conceptual understanding of mechanics and modelling</td></tr>
<tr><td>CO4</td><td colspan="8">Understanding of the sensing and actuating principles for design</td></tr>
<tr><td>CO5</td><td colspan="8">Able to design simple micropressure sensor or accelerometer</td></tr>
<tr><td>UNIT I</td><td colspan="6">Introduction to MEMS</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="9">Microsystems vs. MEMS - Markets for Microsystems and MEMS, Scaling Principles. MEMS and Microsystems, Miniaturization, Typical products- Micro Sensors, MEMS with micro actuators, Micro-accelerometers and Micro fluidics-micro fabrication.</td><td>CO1</td></tr>
<tr><td>UNIT II</td><td colspan="6">MEMS Materials Fabrication Methods</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="9">Silicon material system: Substrates and material properties-Doping– Oxidation – Concepts of Bulk micro machining and Surface Micro machining Additive Processes: Evaporation and sputtering – Chemical vapor deposition (CVD) Lithography- Wet etching: Isotropic– Anisotropic – Etch stops-Dry etching: Vapour – Plasma / RIE – DRIE- Other processing techniques and materials: LIGA–Lift-off– Chemical Mechanical Polishing (CMP)– Soft Lithography and polymers – Wafer Bonding -Process integration:– Process flows– Commercial surface micromachining– Design rules and Maskmaking- Sample Process Flows- A Bulk Micro machined Diaphragm Pressure Sensor-A Surface-Micro machined Suspended Filament.</td><td>CO2</td></tr>
<tr><td>UNIT III</td><td colspan="6">MEMS Mechanics, Modelling,Dynamics, Structures and Electrostatics</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="9">Mechanics of materials: Stress and strain - Plane stress -. Anisotropic materials – Thermal expansion Thin film stress - Material properties - Typical values of MEMS materials- Design limits and safety factors - Lumped element modelling: Conjugate power variables, co-energy, mapping to electrical circuits- Dynamics : Linear first order systems -Linear second order systems -Structures : Bending of beams - Torsion of beams - Axial load and buckling of beams - Effect of residual stress and stress gradient Bending of Plates - Stiffness and natural frequencies – Electrostatics: Parallel plate capacitor - electrostatic actuator - Pull-in.</td><td>CO3</td></tr>
<tr><td>UNIT IV</td><td colspan="6">Advanced MEMS for Sensing and Actuation</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="9">Electromechanical effects: Piezoresistance - Piezoelectricity - Shape memory alloy Thermal effects: Temperature coefficient of resistance - Thermo-electricity – Thermocouples – Micro fluidics: Low Reynolds number fluid flow - Pressure-driven flows - Squeeze film damping – Surface tension and bubbles -Devices: pumps, valves, mixers - Integrated fluidic systems: BioMEMS.</td><td>CO4</td></tr>
<tr><td>UNIT V</td><td colspan="6">Design of Pressure Sensors and Accelerometers</td><td colspan="3">Periods : 9</td></tr>
<tr><td colspan="9">Piezoresistive Pressure Sensor: Sensing Pressure, Piezoresistance- Analytic Formulation in Cubic Materials-Longitudinal and Transverse Piezoresistance - Piezoresistive Coefficients of Silicon- Structural Examples- Signal Conditioning and Calibration. Capacitive Accelerometer: Fundamentals of Quasi-Static Accelerometers, Position Measurementwith Capacitance- Circuits for Capacitance Measurement-Demodulation Methods- Case Study-Specifications- Sensor Design and Modelling- Fabrication and Packaging.</td><td>CO5</td></tr>
<tr><td colspan="2">Lecture Periods: 45</td><td colspan="2">Tutorial Periods: -</td><td colspan="3">Practical Periods: -</td><td colspan="3">Total Periods: 45</td></tr>
<tr><td colspan="10">Reference Books:
1. Stephen D. Senturia, Microsystems Design, Springer International Edition, 2001.
2. Tai Ran Hsu, MEMS & Micro systems Design and Manufacture, Tata McGraw Hill, New.
3. M. Madou, “Fundamentals of Micro Fabrication”, 2nd Edition, CRC Press, 2002.
4. NadimMaluf, An introduction to Micro electro mechanical system design, Artech House, 2000</td></tr>
</table>

CO – PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PSO3
CO1	3	2	1	1	1	2	1	-	-	-	-	1	3	3	3
CO2	3	1	1	1	1	1	1	-	-	-	-	1	3	3	3
CO3	3	2	1	2	2	1	1	-	-	-	-	1	3	3	3
CO4	3	2	1	2	2	1	-	1	-	-	-	1	3	3	3
CO5	3	3	1	2	2	1	-	1	-	-	-	1	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

Department: Electronics and Instrumentation Engineering			Programme: **M.Tech. Instrumentation Engineering**						
Semester:			Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	**T**	**P**		**CA**	**SE**	**TM**
EIZ15	**Adaptive Control**		3	-	-	3	40	60	100
Prerequisite	Control Systems								
Course Outcome	**CO1**	To understand the basics of Adaptive control							
	CO2	Ability to Design the gain scheduling controllers							
	CO3	To design and understand the design of DeterministicSelf-Tuning Regulators							
	CO4	To design and understand the design Stochastic and Predictive Self-Tuning Regulators							
	CO5	The importance and design of Model – Reference Adaptive System							

UNIT – I	**Introduction**	**Periods** : **9**
Introduction- Adaptive Schemes- The adaptive Control Problem- Applications- Real-time parameter estimation -Least squares and regression methods- Estimating parameters in dynamical systems.		**CO1**
UNIT II	**Gain Scheduling**	**Periods** : **9**
Introduction- The principle - Design of gain scheduling controllers- Nonlinear transformations - application of gainscheduling - Auto-tuning techniques - Methods based on Relay feedback.		**CO2**
UNIT III	**Deterministic Self-Tuning Regulators**	**Periods** : **9**
Introduction- Pole Placement design - Indirect Self-tuning regulators - direct self-tuning regulators – Disturbanceswith known characteristics.		**CO3**
UNIT IV	**Stochastic and Predictive Self-Tuning Regulators**	**Periods** : **9**
Introduction – Design of minimum variance controller - Design of moving average controller - stochastic self-tuningregulators.		**CO4**
UNIT V	**Model – Reference Adaptive System**	**Periods** : **9**
Introduction- MIT rule – Determination of adaptation gain - Lyapunov theory –Design of MRAS using Lyapunovtheory – Relations between MRAS and STR.		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1 K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Addison-Wesley Publishing House, 1995.
2 T. Soderstorm and Peter Stoica, “System Identification”, Prentice Hall International, 1989.
3 Ljung L, “System Identification: Theory for the user”, Prentice Hall, Englewood Cliffs, 1987.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	1	1	2	2	-	-	-	-	-	-	-	3	3	3
CO2	3	1	1	3	2	-	-	-	-	-	-	-	3	3	3
CO3	3	2	1	3	3	-	-	-	-	-	-	-	3	3	3
CO4	3	2	1	3	3	-	-	-	-	-	-	-	3	3	3
CO5	3	3	1	3	3	-	-	-	-	-	-	-	3	3	3

Score: **3** – High; **2** – Medium; **1** – Low

<table>
<tr><td colspan="2">Department: Electronics and Instrumentation Engineering</td><td colspan="7">Programme: M.Tech. Instrumentation Engineering</td></tr>
<tr><td colspan="2">Semester:</td><td colspan="4">Course Category Code:</td><td colspan="3">Semester Exam Type: TY</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="3">Periods / Week</td><td>Credit</td><td colspan="3">Maximum Marks</td></tr>
<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EIZ17</td><td>INSTRUMENTATION IN PETROCHEMICAL INDUSTRY</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">know the basics of industrial instrumentation and sensors</td></tr>
</table>

<table>
<tr><td rowspan="5">Course Outcome</td><td>CO1</td><td>Gain knowledge on oil gas production process and important unit operations in a refinery</td></tr>
<tr><td>CO2</td><td>Having gained the process knowledge, ability to develop and analyze mathematical model of selective processes.</td></tr>
<tr><td>CO3</td><td>Able to develop, analyze and select appropriate control strategy for selective unit operations in a refinery.</td></tr>
<tr><td>CO4</td><td>Gain knowledge on the most important chemical derivatives obtained from petroleum products.</td></tr>
<tr><td>CO5</td><td>Understand safety instrumentation followed in process industries</td></tr>
</table>

<table>
<tr><td>UNIT I</td><td>OIL EXTRACTION AND OIL GAS PRODUCTION</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="3">Techniques used for oil discovery – Oil recovery methods – oil rig system - Overview of oil gas production – oil gas separation – Gas treatment and compression – Control and safety systems</td><td>CO1</td></tr>
<tr><td>UNIT II</td><td>IMPORTANT UNIT OPERATIONS IN REFINERY</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="3">Distillation Column – Thermal cracking – Catalytic Cracking – Catalytic reforming – mathematical Modeling and selection of appropriate control strategy – Alkylation – Isomerization</td><td>CO2</td></tr>
<tr><td>UNIT III</td><td>DERIVATIVES FROM PETROLEUM</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="3">Derivatives from methane – Methanol Production – Acetylene production - Derivatives from acetylene –Derivatives from ethylene – Derivatives from propylene.</td><td>CO3</td></tr>
<tr><td>UNIT IV</td><td>IMPORTANT PETROLEUM PRODUCTS & MEASUREMENTS</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="3">BTX from Reformate – Styrene – Ethylene oxide/Ethylene glycol – polyethylene – Polypropylene – PVC production. Parameters to be measured in refinery and petrochemical industry – Selection and maintenance of measuring instruments.</td><td>CO4</td></tr>
<tr><td>UNIT V</td><td>SAFETY IN INSTRUMENTATION SYSTEMS</td><td colspan="2">Periods : 9</td></tr>
<tr><td colspan="3">Hazardous zone classification – Electrical and Intrinsic safety – Explosion suppression and Deluge systems – Flame, fire and smoke detectors – leak detectors – Guidelines and standards – General SIS Design Configurations – Hazard and Risk Assessment – Failure modes – Operation and Maintenance.</td><td>CO5</td></tr>
</table>

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

<u>Reference Books</u>

1. Waddams, A.L., “Chemicals from Petroleum”, Wiley, 1973. (digitized in 2007).
2. Balchen, J.G., and Mumme K.I., “Process Control Structures and Applications”, Von Nostrand Reinhold Company, New York, 1988.
3. Liptak, B.G., “Instrumentation in Process Industries”, Chilton Book Company, 2005. (Digitizedin 2008.)
4. Austin, G.T. and Shreeves, A.G.T., “Chemical Process industries”, McGraw-Hill, 2012.
5. HavardDevold, “Oil and Gas Production Handbook”, ABB, 2006.
6. Paul Gruhn and Harry Cheddie, “Safety Instrumented Systems: Design, Analysis, and Justification”, 2nd Edition, ISA Press, 2006.

<u>CO – PO Mapping</u>

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	3	1	-	2	1	1	-	-	-	1	3	2	1
CO2	3	3	3	1	-	2	1	1	-	-	-	1	3	2	1
CO3	3	3	3	1	-	2	1	1	-	-	-	1	3	2	1
CO4	3	3	3	1	-	2	1	1	-	-	-	1	3	2	1
CO5	3	3	3	1	-	2	1	3	-	-	-	1	3	2	1

<u>Score</u>: **3** – High; **2** – Medium; **1** – Low

Department: Electronics and Instrumentation Engineering			Programme: **M.Tech.(** Instrumentation Engineering **)**						
Semester:			Course Category Code:				Semester Exam Type: **TY**		
Course Code	Course Name		Periods / Week			Credit	Maximum Marks		
			L	T	P		CA	SE	TM
EIZ18	Optimal State Estimation		3	-	-	3	40	60	100
Prerequisite	Mathematics and control systems								
Course Outcome	**CO1**	To understand the conditions and principles of dynamic optimal control systems							
	CO2	To understand the optimization methods and LQR							
	CO3	To provide fundamental knowledgeabout state estimation and Kalman filter.							
	CO4	Conceptual understanding of extended Kalman filter and H-filter							
	CO5	Impart an understanding of the applicability of particle filter							

UNIT I	**Introduction to Optimal Control**	**Periods : 9**
Optimal Control of Dynamic Systems: Necessary & Sufficient Conditions, Euler-Lagrange Equations Principles for Optimal Control: Minimum Principle, Dynamic Programming, Terminal Constraint,Path Constraints and Numerical Optimization		**CO1**
UNIT II	**Optimization Methods**	**Periods : 9**
Minimum-Time and Minimum-Fuel Trajectory Optimization,Neighboring-Optimal Control,Dynamic System Stability,Linear-Quadratic Regulators, Cost Functions and Controller Structures		**CO2**
UNIT III	**Introduction to State Estimation and Kalman Filter**	**Periods : 9**
Review of Matrix Algebra and Matrix Calculus and Probability Theory – Least Square Estimation – Review of stateobservers for Deterministic System- Derivation of the Discrete – time Kalman filter – Kalman filter properties-Kalman filter generalization - Correlated Process and Measurement Noise – Case Studies.		**CO3**
UNIT IV	**Extended Kalman& H- infinity filter**	**Periods : 9**
State Estimation (Kalman-Bucy Filter) for Continuous-Time Systems, Nonlinear State Estimation (Extended Kalman Filters) The H- infinity filter-Introduction - Kalman filter Limitations - A game theory Approach to H- infinity filtering – Steady state H- infinity Filtering -Mixed Kalman / H- Infinity filtering - Robust Kalman / H- infinity filtering -Constrained H-infinity filtering – Case Studies.		**CO4**
UNIT V	**Particle Filter**	**Periods : 9**
Bayesian state Estimation -Particle filtering -Implementation issues- Sample Impoverishment - Particle filter withEKF as proposal - Unscented Particle filter - Case Studies		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

<u>Reference Books</u>

1. Donald Kirk, Optimal Control Theory, Prentice Hall, 1970.
2. B.D.O.Anderson and J.B.Moore, Optimal Control: Linear Quadratic Methods, Prentice Hall, 2007.
3. BrankoRistic, Sanjeev Arulampalam, Neil Goodon, “Beyond the Kalman Filter: Particle ilters for Tracking Application”, Artech House Publishers, Boston, London, 2004.
4. Dan Simon, “Optimal State Estimation Kalman, H-infinity and Non-linear Approaches”, John Wiley and Sons, 2006.

<u>CO – PO Mapping</u>

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	3	3	3	3	2	-	-	-	-	-	1	3	3	1
CO2	3	3	3	3	3	1	-	-	-	-	-	1	3	3	1
CO3	3	3	3	3	3	1	-	-	-	-	-	1	3	3	1
CO4	3	3	3	3	3	1	-	-	-	-	-	1	3	3	1
CO5	3	3	3	3	3	1	-	-	-	-	-	1	3	3	1

<u>Score</u>: **3** – High; **2** – Medium; **1** – Low

Department: ELECTRONICS AND INSTRUMENTATION ENGINEERING			Programme: **M.Tech. INSTRUMENTATION ENGINEERING**					
Semester:			Course Category Code:			Semester Exam Type: **TY**		
Course Code	Course Name	Periods / Week			Credit	Maximum Marks		
		L	T	P		CA	SE	TM
EIZ19	OPTIMAL CONTROL	3	-	-	3	40	60	100
Prerequisite	CONTROL SYSYTEMS							

Course Outcome	**CO1**	Ability to explain different type of optimal control problems such as time-optimal, fuel optimal, energy optimal control problems
	CO2	Ability to design Linear Quadratic Regulator for Time-invariant and Time-varying Linear system (Continuous time and Discrete-time systems)
	CO3	Ability to design optimal controller using Dynamic Programming Approach and H-J-B equation.
	CO4	Ability to Explain the Pontryagin Minimum Principle.
	CO5	Ability to design optimal controller in the presence of state constraints and time optimal controller.

UNIT I	**CALCULUS OF VARIATIONS AND OPTIMAL CONTROL**	**Periods : 9**
Introduction – Performance Index- Constraints – Formal statement of optimal control system Calculus of variations – Function, Functional, Increment, Differential and variation and optimum of function and functional – The basic variational problem Extrema of functions and functional with conditions – variational approach to optimal control system		**CO1**
UNIT II	**LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM**	**Periods : 9**
Problem formulation – Finite time Linear Quadratic regulator – Infinite time LQR system: Time Varying case- Time-invariant case – Stability issues of Time-invariant regulator – Linear Quadratic Tracking system: Fine time case and Infinite time case		**CO2**
UNIT III	**DISCRETE TIME OPTIMAL CONTROL SYSTEMS**	**Periods : 9**
Variational calculus for Discrete time systems – Discrete time optimal control systems:-Fixed final state and open-loop optimal control and Free-final state and open-loop optimal control - Discrete time linear state regulator system – Steady state regulator system		**CO3**
UNIT IV	**PONTRYAGIN MINIMUM PRINCIPLE**	**Periods : 9**
Pontryagin Minimum Principle – Dynamic Programming:- Principle of optimality, optimal control using Dynamic Programming – Optimal Control of Continuous time and Discrete-time systems – Hamilton-Jacobi-Bellman Equation – LQR system using H-J-B equation		**CO4**
UNIT V	**CONSTRAINED OPTIMAL CONTROL SYSTEMS**	**Periods : 9**
Time optimal control systems – Fuel Optimal Control Systems- Energy Optimal Control Systems Optimal Control Systems with State Constraints		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1 Donald E. Kirk, Optimal Control Theory – An Introduction, Dover Publications, Inc. Mineola, New York, 2004.
2 D. Subbaram Naidu, Optimal Control Systems, CRC Press, New York, 2003.
3 Frank L. Lewis, DragunaVrabie, Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley Publication, 2012.

CO – PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	2	2	1	1	1	-	-	-	-	-	-	-	-	-	-
CO2	2	2	1	1	1	-	-	-	-	-	-	-	-	-	-
CO3	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-
CO4	2	3	2	2	2	-	-	-	-	-	-	-	-	-	-
CO5	2	3	2	2	2	-	-	-	-	-	-	-	-	-	-

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<tr><td colspan="2">Semester:</td><td colspan="4">Course Category Code:</td><td colspan="3">Semester Exam Type: TY</td></tr>
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<tr><td>L</td><td>T</td><td>P</td><td></td><td>CA</td><td>SE</td><td>TM</td></tr>
<tr><td>EIZ20</td><td>AUTOMOTIVE INSTRUMENTATION</td><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Prerequisite</td><td colspan="8">Measurement and CONTROL SYSYTEMS</td></tr>
</table>

Course Objectives	**CO1**	To impart knowledge to the students in the principles of operation and constructional details ofvarious Automotive Electrical and Electronic Systems
	CO2	To understand the need for starter batteries, starter motor and alternator in the vehicle
	CO3	To differentiate the conventional and modern vehicle architecture and the data transfer amongthe different electronic control unit using different communication protocols
	CO4	To list common types of sensor and actuators used in vehicles.
	CO5	To understand dash – Board Instruments, various sensors and networking in vehicles.

UNIT I	**BATTERY AND STARTING SYSTEMS**	**Periods : 9**
Types of Batteries – Principle, Construction and Electrochemical action of Lead – Acid battery, Electrolyte, Efficiency, Rating, Charging, Testing and Maintenance. Starting System, Starter Motors – Characteristics, Capacity requirements. Drive Mechanisms. Starter Switches.		**CO1**
UNIT II	**CHARGING AND LIGHTING SYSTEMS**	**Periods : 9**
D.C. Generators and Alternators their Characteristics. Control cutout, Electrical, Electromechanical and electronic regulators. Regulations for charging. Wiring Requirements, Insulated and earth return system, details of head light and side light, LED lighting system, head light dazzling and preventive methods. Lighting design.		**CO2**
UNIT III	**ELECTRONIC IGNITION AND INJECTION SYSTEMS**	**Periods : 9**
Types of electronic ignition systems - variable ignition timing, distributor less ignition. Spark timing control. TBI, MPFI, GDI Systems. Engine mapping		**CO3**
UNIT IV	**ELECTRICAL SYSTEMS**	**Periods : 9**
Warning and alarm instruments : Brake actuation warning system, traficators, flash system, oil pressure warning system, engine over heat warning system, air pressure warning system, speed warning system, door lock indicators, neutral gear indicator, horn design, permanent magnet horn, air & music horns. Wind shield wiper. window washer, instrument wiring system and electromagnetic interference suppression, wiring circuits for instruments, electronic instruments, dash board illumination.		**CO4**
UNIT V	**MICROPROCESSOR IN AUTOMOBILES**	**Periods : 9**
Microprocessor And Microcomputer controlled devices in automobiles such as instrument cluster, Voice warning system, Travel information system, Keyless entry system. Environmental requirements (vibration, Temperature and EMI)		**CO5**

Lecture Periods: 45	**Tutorial Periods: -**	**Practical Periods: -**	**Total Periods: 45**

Reference Books

1. Judge. A.W., Modern Electrical Equipment of Automobiles, Chapman & Hall, London, 1992.
2. William B. Ribbens -Understanding Automotive Electronics, 5th edition- Butter worth Heinemann, 199882
3. Young. A.P., & Griffiths. L., Automobile Electrical Equipment, English Language Book Society & New Press, 1990.
4. Vinal. G.W., Storage Batteries, John Wiley & Sons inc., New York, 1985.
5. Crouse.W.H., Automobile Electrical Equipment, McGraw Hill Book Co Inc., New York, 1980.
6. Spreadbury.F.G., Electrical Ignition Equipment, Constable & Co Ltd., London, 1962.
7. Robert N Brady Automotive Computers and Digital Instrumentation, Prentice Hall, Eagle Wood Cliffs, New Jersey, 1988.

MAPPING FLIGHT INSTRUMENTATIONOUTCOMES WITH POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	3		2		-			1
CO2	2				1			2	2
CO3					1	1			
CO4		3	3					2	
CO5	3	1	2			2			1