SEMESTER S7

INSTRUMENTATION SYSTEM DESIGN

Course Code	PEAET795	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCAET602 Industrial Instrumentation, PCAET502 Process Dynamics and Control	Course Type	Theory

Course Objectives:

1. To impart knowledge on the design of signal conditioning circuits required for various sensors
2. To develop the skills needed to design transmitters, Analog/Digital PID controller, Data loggers and Alarm Annunciator
3. To familiarize with the design orifice and control valve sizing

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SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction and Standards** Concepts of instrument design, functional requirements and specifications. Standards – Military, Industrial, and Commercial standards. BIS standards, ANSI standards, NEMA standards, DIN standards. **Piping and Instrumentation Diagram** P & I D Symbols, line numbering, line schedule, overview of various stages in P&I D development, P&I D for pumps, compressors process vessels, absorber and evaporator. **Design of signal conditioning circuits** Design of V/I Converter and I/V Converter, Signal conditioning circuit for pH electrodes, Design of Air-purge Level Measurement, Signal conditioning circuit for Thermocouple, RTD and Thermistor, Overview of Cold Junction Compensation and Linearization – software and Hardware approaches.	9

2	**Design of Transmitters** – Overview of 2 wire and 4 wire transmitters, Design of RTD based Temperature Transmitter, Thermocouple based Temperature Transmitter and Smart Transmitters. **Control Valves** - Characteristics, valve equation, types of valves- Globe valve, ball valve, gate valve, butterfly valve, needle valve, valve positioner, valve selection criteria.	**9**
3	**Orifice and Control valve sizing** - Orifice, Venturi and flow nozzle sizing - Liquid, Gas and steam services. Control valve sizing – Liquid, Gas and steam services. Overview of Rotameter Design **Design of Data logger and PID controller** Design of ON/OFF Controller using Linear Integrated Circuits, Electronic PID Controller, Basics of Microcontroller based digital two-degree of freedom PID Controller, Microcontroller based Data Logger, Basic architecture of PC based Data Acquisition Cards.	**9**
4	**Control Panel Design** Basics of operating console and control room panel design. Control room environment for electronic equipment - heat dissipation, forced air circulation and humidity considerations. Grounding and shielding- protection against electrostatic discharge. Design of Alarm and Annunciation circuit - Alarm and Annunciation Circuits using Analog and Digital Circuits – Design of Programmable Logic Controller for any two simple applications	**9**

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Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Ex*	*Evaluate*	*Analyse*	*Total*
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyse): 20 marks

- The project needs to be done as an individual project.
- The project can be done as design and simulation or complete hardware implementation
- Simulations may be done using tools like LabVIEW/MATLAB/Scilab
- The students should design any one of the following systems with industrial standards

1. An industrial instrumentation system that can measure physical parameters like temperature, level, humidity or flow with P&I diagrams
2. An industrial Data logger/ Data acquisition system
3. Design and simulation of controllers suitable for various processes.
4. A PLC based automation system.

At the completion of the project, the students should be familiar with the following:

- Select an appropriate components for measurement or control
- Interface various sensors/actuators to the digital systems
- Parameters to be considered while developing the system for industrial purposes
- Instrumentation drawings
- Use of simulation tools for industrial system design

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The project deliverables consist of the following components:

- Detailed design specifications
- Identification and resolution of technical challenges
- Designed and developed algorithms
- Implementation results and performance evaluations
- Comprehensive project report, incorporating methodology, results, challenges, and recommendations.

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. Each question carries 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Design signal conditioning circuits for temperature sensors, V/I and I/V converters	**K3**
CO2	Design of transmitters, data logger, PID controller and alarm circuits	**K3**
CO3	Carry out orifice and control valve sizing for different services	**K3**
CO4	Design control panels	**K3**
CO5	Design automation systems with PLCs	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3									3
CO2	3	3	3									3
CO3	3	3	3									3
CO4	3	3	3									3
CO5	3	3	3		3							3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

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Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Instrument Engineers Handbook - Process Control and Optimization	Bela G. Liptak	CRC Press	4th Edition, Vol.2, 2008.
2	Introduction to Process Engineering and Design	Thakore and Bhatt	McGraw Hill	2nd Edition, 2007
3	Process Control Instrumentation Technology	C. D. Johnson	Prentice Hall	8th Edition, 2015
4	Electronic Instrument Design	Kim Fowler	Oxford	Reprint 2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Measurement Systems	Bentley	Pearson Education	4th Edition, 2015
2	Flow Measurement Engineering Handbook	R.W. Miller	McGraw Hill	1996.
3	Measurement Systems Application and Design	E.O. Dobelin	McGraw Hill	4th Edition, 1989
4	Process/Industrial Instruments and Controls Handbook	Gregory K. McMillan, Douglas M. Considine	Mc Graw Hill	5th Edition, 1999
5	Hand Book of transducer	Harry N Nortan	PHI	1st Edition, 1989
6	A Course in Electronic Measurements and Instrumentation	A K Sawhney	Dhanpath Rai & Co	2021
7	Piping and Instrumentation Diagram Development	Moe Toghraei	Wiley	1st Edition, 2019

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Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/105/108105064/
2	https://archive.nptel.ac.in/courses/108/105/108105064/
3	https://nptel.ac.in/courses/108105088
4	https://nptel.ac.in/courses/108105088

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