GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Instrumentation and Control Engineering

Subject Code : DI04017011

Subject Name : Process Instrumentation-II

w. e. f. Academic Year:	2025-26
Semester:	4th
Category of the Course:	PCC

Prerequisite:	Students should have basic knowledge of the measurement principles covered in Process Instrumentation–I, including pressure, flow, speed, and humidity measurement, along with fundamentals of electrical and electronic circuits, sensors and transducers and signal conditioning. This foundation will help them learn the new topics in this subject, such as temperature and level measurement, temperature and level transmitters, and force, torque, and vibration instruments.
Rationale:	In the present industrial scenario, accurate and precise measurement of process parameters such as temperature, level, force, torque, and vibration is essential for the safe and efficient operation of process industries. Diploma engineers must be able to identify, select, calibrate, troubleshoot, and maintain various process instrumentation systems. This course is therefore designed to equip students with the skills required to operate and test different types of process instruments used for measuring temperature, level, force, torque, and vibration.

COURSE OUTCOME:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
1	Apply temperature measurement principles using contact and non-contact instruments.	U A
2	Classify and compare various level measurement methods and switches.	R U A
3	Operate and interpret temperature and level transmitters.	U A
4	Evaluate force and torque measuring instruments for industrial use.	U A
5	Select suitable vibration measuring instruments for industrial monitoring.	R U

**Revised Bloom's Taxonomy (RBT)*

TEACHING AND EXAMINATION SCHEME:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE(E)	PA(M)	PA(I)	ESE(V)	
3	0	2	4	70	30	20	30	150

COURSE CONTENT:

Unit	Topics and Sub-topics	No. Of Hrs.	% Weightage
Unit-I Temperature Measurement Techniques	**1.1 Introduction to Temperature Measurement** • Heat and Temperature – definition • Temperature Scales: Celsius, Fahrenheit, and Kelvin (relationships and conversions) **1.2 Expansion Thermometers** • Construction, working, merits and demerits of: o Solid expansion thermometer o Liquid expansion thermometer **1.3 Filled System Thermometers** • Construction, working, applications, merits and demerits of: o Class I – Liquid filled systems o Class II – Vapour pressure systems o Class III – Gas filled systems o Class V – Mercury filled systems • Sources of error in filled system thermometry • Effects influencing filled system thermometers: o Ambient effect o Head effect o Radiation effect o Immersion effect o Dip effect **1.4 Thermocouples** • Thermocouple Principles o Seebeck, Peltier and Thomson effects. • Thermoelectric Laws o Law of Homogeneous Materials o Law of Intermediate Metals o Law of Intermediate Temperatures • Cold Junction Compensation o Need for cold junction compensation and commonly used CJC methods. • Thermocouple Types & Extension Wires o Positive and negative extension wires used for thermocouple types B, E, J, K, R, S, T. • Selection Criteria o Factors considered for selecting a thermocouple for industrial applications.	17	35 %

	• Thermowell
	  ○ Purpose and importance of thermowell in thermocouple installations.
	• Thermopile
	  ○ Meaning of thermopile and its requirement.
	• Thermocouple Temperature Calculation
	  ○ Converting thermocouple output (mV) into temperature (°C) using standard calibration tables (ITS-90).
	1.5 Resistance Temperature Detectors (RTD)
	• Industrial RTD construction
	• Lead wire compensation – need and concept
	• Measuring circuits for RTD:
	  ○ 2-wire
	  ○ 3-wire
	  ○ 4-wire
	1.6 Thermistors
	• Working principle and characteristics
	• Temperature measuring circuits for thermistors
	1.7 Integrated Circuit (IC) Temperature Sensors
	• Working Principle of IC-based temperature sensors
	• Comparison of temperature response of:
	  ○ Thermocouple
	  ○ RTD
	  ○ Thermistor
	  ○ IC temperature sensor
	1.8 Non-contact Type Thermometry
	• Basic concepts:
	  ○ Emissivity
	  ○ Black body concept
	  ○ Stefan–Boltzmann Law
	• Construction, working, merits, demerits and applications of:
	  ○ Radiation pyrometer
	  ○ Optical pyrometer
	  ○ Ultrasonic thermometry
	  ○ Laser thermometry
	  ○ Optical fiber thermometry
	  ○ Infra-red thermometer		

	• Sources of error in non-contact temperature measurement **1.9 Temperature Switches and Thermostats** • Operation of temperature switches and thermostats • Calibration procedure for temperature measuring devices		
Unit-II Level Measurement Techniques	**2.1 Introduction to Level Measurement** • Definition of level measurement • Units used for level measurement • Importance of level measurement in industries **2.2 Classification of Level Measurement Methods** 2.2.1 Direct Methods • Construction, working, applications, merits and demerits of: o Sight Glass / Gauge Glass 2.2.2 Indirect Methods 2.2.2.1 Hydrostatic Pressure Type • Construction, working, applications, merits and demerits of: o Pressure Gauge Type o Air Purge System 2.2.2.2 Electrical / Electronic Methods • Construction, working, applications, merits and demerits of: o Capacitance Level Detector o Radiometric (Radiation) Level Detector o Ultrasonic Level Detector o Radar Level Detector (Non-contact radar & Guided wave radar) o Laser Level Sensor o Differential Pressure (DP) Type Level Measurement **2.3 Level switches** • Construction and working of: o Float type level switch o Displacer type level switch o Conductivity level switch o Tuning fork level switch o Rotating paddle level switch o Microwave level switch	13	25 %

Unit – III Temperature and level Transmitters	**3.1 Introduction to Transmitters**
	• Definition of a transmitter
	• Purpose of using transmitters in industrial measurement
	3.2 Electronic Temperature Transmitters
	• Construction
	• Working principle
	• Block diagram
	3.3 Level Transmitters
	3.3.1 Pressure (Hydrostatic) Type Level Transmitter
	• Construction
	• Working principle
	• Applications
	3.3.2 Differential Pressure (DP) Type Level Transmitter
	• Pneumatic & Electronic type
	  ○ Construction
	  ○ Working
	  ○ Applications
	3.4 Zero Suppression and Zero Elevation
	• Concept of zero suppression
	• Concept of zero elevation
	• Application in level measurement using DP transmitters
		8	20 %

Unit IV Force and Torque Measurement Techniques	**4.1 Force** 4.1.1 Definition and Units • Definition of force • Units of force 4.1.2 Construction, working, applications, merits and demerits of: • Elastic Force Meters • Load Cells **4.2 Torque** 4.2.1 Definition and Units • Definition of torque • Units of torque 4.2.2 Construction, working, applications, merits and demerits of: • Strain Gauge Torsion Meter • Electrical Torsion Meter • Mechanical Torsion Meter	4	14 %

Unit – V Vibration Measurement Techniques	**5.1 Introduction to Vibration Measurement** • Definition of vibration • Need of vibration measurement in industry • Units of vibration **5.2 Vibration Sensors** 5.2.1 Construction, Working principle, applications, merits and demerits of: • Mass–Spring (Seismic) Type Vibration Sensor • Piezoelectric Vibration Sensor	3	6 %
	Total	**45 Hrs**	**100%**

SUGGESTED PRACTICAL EXERCISES:

The following practical outcomes (PrOs) that are the sub-components of the COs. *Some of the* ***PrOs*** *marked* ***'*'*** *are compulsory, as they are crucial for that particular CO. These PrOs need to be attained at least at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

Sr. No.	Practical Outcomes (PrOs)	Approx. Hrs. Required
1	Perform temperature measurement using expansion thermometer.	04
2	Verify the law of intermediate metal for the available type of thermocouple.	02
3	Test the effect of reference junction temperature on given thermocouple	04
4	Convert output of thermocouple (mV) into temperature (˚C) using corresponding thermocouple calibration table.	04
5	Measure the temperature using RTD and Test.	04
6	Calculate temperature coefficient of resistance using RTD.	02
7	Measure the temperature using Thermistors and Plot the characteristic curve.	04
8	Measure the temperature of heating element using Optical Pyrometer.	04
9	Measure the temperature of heating element using radiation Pyrometer.	04
10	Test the operation of temperature switch at given Temp.	02
11	Measure the temperature using fiber Optic thermometer.	02

Sr. No.	Practical Outcomes (PrOs)	Approx. Hrs. Required
12	Measure the temperature using infrared thermometer.	02
13	Measurement of level in water tank with the help of sight glass.	04
14	Measurement of level in water tank with the help of pressure gauge.	04
15	Measurement of level in a tank using capacitive transducer.	04
16	Test Float type level switch.	04
17	Test Rotating paddle level switch.	04
18	Test Conductivity level switch.	04
19	Use differential pressure type level transmitter for given range & Test.	04
20	Use Electronic Temperature transmitters for given range & Test.	04
21	Demonstrate zero suppression and zero elevation using DP transmitter.	04
22	Measure torsion by electrical torsion meter.	04
23	Use load cell and test for performance.	04
24	Measure vibration by vibration analyser.	04

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare experimental setup	30
2	Operate the equipment setup or circuit	10

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
3	Follow safe practices measures	20
4	Record observations correctly	20
5	Interpret the result and conclude	20
Total		**100**

MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED:

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement of them by the administrators/management of the institutes. This will ensure conduction of practical in all institutions across the state in proper way so that the desired skills are developed in students.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Multimeter	All
2	DC power supply (-30 →0→+30 V with at least 1A current capacity)	All
3	Electrical tool kit.	All
4	Circuit/Trainer board/ Demonstration modules of Thermocouples, RTDs, Thermistors	1-7
5	Temperature Switches, Optical Pyrometer, Radiation Pyrometer	8-10
6	Sight Glass type Level Indicator	13
7	Float type, Displacer type and Capacitance type Level Switches	16-18
8	Fiber Optic Thermometer, Ultrasonic Thermometer, Laser Thermometer	11-12
9	Capacitance type Level Transducer	15
10	Electronic Temperature transmitters	20
11	Differential pressure type Level Transmitter	19, 21
12	Load Cell	23
13	Vibration Analyzer	24
14	Electrical Torsion Meter	22

AFFECTIVE DOMAIN OUTCOMES:

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Work as a leader/a team member for assigned student activity.
b) Follow safety practices and procedure in Lab.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day-to-day observation

SUGGESTED STUDENT ACTIVITIES:

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Industrial visit for students. (Chemical industries, petroleum industries, production industries.) So that students can have exposure to the real industrial realm.
b) Department should arrange a workshop/seminar where students can have interaction with industry personnel.
c) Videos/Animation for different devices should be shown. Download videos of different industries from various YouTube channels like how it's made, how stuff works and show in class and discuss instrumentation used in that industry.
d) Model making.

SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any):

Following Sample strategies teacher can use to accelerate the attainment of the various outcomes in this course:

1. Use instrumentation trainer kits to demonstrate real-time measurement of pressure, temperature, flow, and level and to perform hands-on calibration using standard instruments.
2. Utilize industrial process simulation software such as MATLAB/Simulink, LabVIEW, Factory I/O, or SCADA simulators to visualize process behaviour and signal conditioning.
3. Demonstrate measurement principles using cutaway models and working models of various industrial instruments.
4. Use virtual labs and online platforms (NPTEL/AICTE) for performing simulated experiments related to process measurement.
5. Arrange field visits to process industries for exposure to real-time process parameters, control loops, and industrial instrumentation systems.
6. Implement case study–based learning focusing on transmitter faults, calibration issues, and troubleshooting scenarios from industries.

7. Apply problem-based learning (PBL) by assigning real-world measurement and instrumentation problems for student analysis.
8. Demonstrate standard calibration procedures, including zero, span, linearity, and hysteresis checks, using proper calibration documentation.
9. Use videos, animations, and AR/VR content to explain the working of pressure, temperature, flow, and level measurement devices.
10. Assign mini-projects and hands-on activities related to process parameter measurement, signal conditioning, and microcontroller/PLC interfacing.
11. Promote group activities and peer learning for calibration work, instrument connections, and laboratory data analysis.
12. Use standard industrial documentation such as P&ID diagrams, datasheets, instrument index, and loop diagrams during teaching and assignments.
13. Adopt flipped classroom techniques by providing pre-class learning materials and conducting in-class problem-solving discussions.

SUGGESTED MICRO-PROJECTS:

1. Thermocouple Characterization
2. RTD (Pt100) Linearity Check
3. Level Switch Testing Panel
4. DP Transmitter Zero Suppression/Elevation Demonstration
5. Load Cell Calibration Chart Development
6. Vibration Measurement on Motor Shaft

SUGGESTED LEARNING RESOURCES:

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Process Measurement and Analysis	B. G. Liptak	I.S.A
2	Industrial Instrumentation	D. P. Eckman	Wiley Eastern Limited, New Delhi
3	Industrial Instrumentation	S.K. Singh	Tata Mc Graw Hill, New Delhi
4	Mechanical Measurements	D. S. Kumar	Metropolitan Book Company, New Delhi
5	Process Instrumentation and Control	A.P. Kulkarni	Nirali Prakashan, Pune
6	Mechanical and Industrial measurements	R.K. Jain	Khanna publication, New Delhi
7	Industrial Instrumentation	Krishnaswamy, K. and S. Vijayachitra,	New Age International Publication, New Delhi

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
8	Mechanical Measurements and Instrumentation & control	A K Sawhney	DHANPAT RAI & Co
9	Applied Instrumentation in Process Industries Vol-3a	William G Adrews	Gulf Publication Company
10	Lessons In Industrial Instrumentation (Version 3.01)	Tony R. Kuphaldt	Samurai Media Limited
11	Measurement Systems Application and Design	E O Doeblin D N Manik	Tata Mc Graw Hill

SUGGESTED LEARNING WEBSITES:

1. https://www.nptel.com
2. https://instrumentationtools.com
3. https://www.vlab.co.in/participating-institute-coe-pune
4. https://vlab.amrita.edu/?sub=1&brch=282&sim=1511&cnt=1
5. http://www.ni.com
6. https://www.engineeringtoolbox.com
7. https://www.omega.com/en-us/resources
8. https://www.emerson.com
9. https://www.keyence.com
10. https://www.yokogawa.com/library/resources/white-papers
11. https://ocw.mit.edu/
12. https://www.ptc.com/en/learning

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