GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)

Semester- IV

Course Title: Process Instrumentation-II

(Course Code: 4341701)

Diploma program in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	4th Semester

1. RATIONALE

In the present industrial scenario, the role of the process instrumentation is important for accurate and precise measurement of process parameters such as temperature, level, force, torque, vibration etc. is very essential for successful running of a process industry. Diploma engineers should therefore be able to identify, select, calibrate troubleshooting and maintain the different process instrumentation systems. Therefore, this course has been designed so that students will develop skill to test the different types of process instruments required for the parameters such as temperature, level, force, torque, vibration etc.

2. COMPETENCY ('Program Outcome' according to NBA Terminology)

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **To develop skill for operating and testing various temperature ,level ,force, torque and vibration measuring instruments.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

a) CO1: Apply working principles of temperature and level sensors.
b) CO2: Select instrument for measurement of temperature and level.
c) CO3: Use temperature and level instruments.
d) CO4: Test temperature and level instruments.
e) CO5: Select an instrument for Vibration, Force and Torque measurement.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	4	5	30*	70	50	50	200

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the subcomponents of the COs.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Perform temperature measurement using expansion thermometer	1	04
2	Verify the law of intermediate metal for the available type of thermocouple.	1	02
3	Test the effect of reference junction temperature on given thermocouple	1	04
4	Convert output of thermocouple (mV) into temperature(˚C) using corresponding thermocouple calibration table	1	04
5	Measure the temperature using RTD and Test	1	04
6	Calculate temperature coefficient of resistance using RTD	1	02
7	Measure the temperature using Thermistors and Plot the characteristic curve	1	04
8	Measure the temperature of heating element using Optical Pyrometer	1	04
9	Measure the temperature of heating element using radiation Pyrometer	1	04
10	Test the operation of temperature switch at given temp	1	02
11	Measure the temperature using fiber Optic thermometer.	1	02
12	Measure the temperature using infrared thermometer	1	02
13	Measurement of level in water tank with the help of sight glass.	2	04
14	Measurement of level in water tank with the help of pressure gauge.	2	04
15	Measurement of level in a tank using capacitive transducer.	2	04
16	Test Float type level switch	2	04
17	Test Rotating paddle level switch	2	04
18	Test Conductivity level switch	2	04
19	Use differential pressure type level transmitter for given range & Test.	3	04

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
20	Use Electronic Temperature transmitters for given range & Test.	3	04
21	Measure torsion by electrical torsion meter	4	04
22	Use load cell and test for performance	4	04
23	Measure vibration by vibration analyzer.	5	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.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the Pros is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications.	PrO. No.
1	Function generator (sine, square, triangle etc. with frequency range 10 Hz to 100 kHz	15
2	Measuring equipment's like CRO (preferably dual channel, 20Mhz)	15
3	Multi meter	All

4	DC power supply (-30 →0→+30 V with at least 1A current capacity)	All
5	Electrical tool kit.	All
6	Circuit/Trainer board/ Demonstration modules of Thermocouples, RTDs, Thermistors.	1-7
7	Temperature Switches, Optical Pyrometer, Radiation Pyrometer	8-10
8	Sight Glass type Level Indicator	13
9	Float type, Displacer type and Capacitance type Level Switches	16-18
10	Fiber Optic Thermometer, Ultrasonic Thermometer, Laser Thermometer	11-12
11	Capacitance type Level Transducer	15
12	Electronic Temperature transmitters	20
13	Differential pressure type Level Transmitter	19
14	Load Cell	22
15	Vibration Analyzer	23
16	Electrical Torsion Meter	21

7. 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.
b. Follow safety practices while using electrical appliances.
c. Practice environmentally friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of Revised Bloom's taxonomy in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)		Topics and Sub-topics	
Unit-I Temperature Measurement Techniques	1a	Define heat and temperature	1.1	Introduction: Heat, Temperature
	1b	List various temperature scales and relate them.	1.2	Temperature Scale
			1.3	Expansion thermometer
	1c	Describe construction and working of solid and liquid expansion thermometer.	1.3.1	Solid expansion thermometer
	1d	Enlist merits and demerits of expansion thermometer	1.3.2	Liquid expansion thermometer
	1e	Explain construction and working of following filled system thermometers: (1) Class I (2) Class II (3) Class III (4) Class V	1.4	Filled system thermometer
	1f	Enlist applications, merits and demerits of filled system thermometer	1.4.1	Class I-Liquid Filled Systems
	1g	List sources of error in filled system thermometry.	1.4.2	Class II- Vapor Systems
	1h	State ambient effect, head effect, radiation effect, immersion effect and dip effect.	1.4.3	Class III- Gas Filled Systems
			1.4.4	Class V- Mercury Filled Systems
	1i	Describe See beck effect, Peltier effect and Thomson effect	1.5	Thermocouples
	1j	State and explain thermoelectric laws.	1.5.1	Thermocouple effect
	1k	Explain cold junction compensation method used in thermocouple	1.5.2	Thermocouple Laws
	1l	State positive and negative extension wires used in following type of thermocouples: B, E, J, K, R, S, and T	1.5.3	Cold junction compensation
	1m	State the criteria for selection of thermocouple.	1.5.4	Thermocouple wires and extension wires
	1n	State importance of thermowell in thermometry	1.5.5	Thermocouple selection criteria

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)		Topics and Sub-topics	
	1o	Define thermopile and state its need.	1.5.5	Thermowell
	1p	Describe the output of thermocouple (mV) converted to corresponding temperature value using thermocouple calibration table.	1.5.6	Thermocouple temperature calculation
	1q	Describe construction of industrial RTD	1.6	Resistance Temperature Detector (RTD)
	1r	State need of lead wire compensation in RTD	1.6.1	2-Wire RTD
	1s	Describe measuring circuit of RTD. (2 wire, 3-wire, 4-wire)	1.6.2	3-Wire RTD
			1.6.3	4-Wire RTD
	1t	Describe temperature measuring circuit of thermistor.	1.7	Thermistor
	1u	Explain Integrated Circuit (IC) based temperature sensors	1.8	Integrated Circuit (IC) based Temperature sensors
	1v	Compare temperature response of Thermocouple, RTD, thermistor and IC sensor		
	1z	Define emissivity, Black body concept, Stefan Boltzmann Law.	1.9	Non-contact type thermometry
	1x	Explain construction and working of non-contact type of thermometry (1.9.1 to 1.9.5)	1.9.1	Radiation pyrometer
	1y	State merits and demerits of non-contact type thermometer	1.9.2	Optical pyrometer
	1z	List sources of error in non-contact type thermometry	1.9.3	Ultrasonic thermometry
	1aa	Describe operation of Temperature switches and thermostats	1.9.4	Laser Thermometry
	1bb	State calibration procedure for temperature measuring devices.	1.9.5	Optical fiber thermometry **Infra-red thermometer**
	1cc	Describe operation of the temperature switch.	1.10	Temperature Switch

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)		Topics and Sub-topics	
	1dd	State importance of temperature classification	1.11	Temperature Classification
	1ee	List Temperature code classification(T1 to T6)		
Unit-II Level Measurement Techniques	2a	State units for level measurement.	2.1	Introduction to level measurement.
	2b	State importance of level measurement in process industries.	2.2	Level measurement Importance and Units.
	2c	Classify methods of level measurement.	2.2	Level Measurement method
	2d	Explain working and construction of level measurement methods (2.2)	2.2.1	Direct methods
	2e	State merits and demerit of various level measuring methods	2.2.1.1	Sight glass/Gauge glass
	2f	Enlist Applications for various level measuring methods	2.2.2	Indirect methods
	2g	Explain working and construction of various levels switches (2.3)	2.2.2.1	Hydrostatic pressure type indirect methods
	2f	State calibration procedure for level measuring devices.	2.2.2.1a	Pressure gauge type
			2.2.2.1b	Air purge system
			2.2.2.2	Electrical indirect methods
			2.2.2.2a	Capacitance level detector
			2.2.2.2b	Radiation (Radiometric) level detector
			2.2.2.2c	Ultrasonic level detector.
			2.2.2.2d	Radar (Non-contact & Guided wave radar) level detector.
			2.2.2.2e	Laser Level Sensors
			2.2.2.2f	Differential pressure type level measurement
			2.3	Level switches

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)		Topics and Sub-topics	
			2.3.1	Float type level switch
			2.3.2	Displacer level switch
			2.3.3	Conductivity level switch
			2.3.4	Tuning fork level switch
			2.3.5	Rotating paddle level switch
			2.3.6	Microwave level switch
Unit – III Temperature and level Transmitters	3a	Define transmitter.	3.1	Electronic temperature transmitters
	3b	Explain electronic temperature transmitter with neat schematic diagram.	3.2	Level transmitter
	3c	Explain working and construction of pressure type level transmitter with neat sketch	3.2.1	Differential pressure type level transmitter
	3d	Enlist applications of transmitters	3.2.1a	Pneumatic type
	3e	Describe the concept of Zero suppression and Elevation for level transmitter.	3.2.1b	Electronic type
Unit IV Force and Torque Measurement Techniques	4a	Define Force and Torque	4.1	Force
	4b	State units of Force and Torque	4.1. 1	Elastic force meters.
	4c	Explain working and construction of listed force transducers.	4.1. 2	Load cells
	4d	Explain working and construction of listed torque transducers.	4.2	Torque
			4.2. 1	Strain gauge torsion meter
			4.2. 2	Electrical torsion meter
			4.2.3	Mechanical torsion meter
Unit – V Vibration Measurement Techniques	5a	Define vibration	5.1	Vibration.
	5b	Explain working and construction of vibration sensor	5.2	Vibration Sensors:
	5c	Enlist applications of vibration sensors	5.2.1	Mass spring seismic senso
	5d	Enlist merits and demerits of vibration sensors	5.2.2	Piezo-electric sensor

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R	U	A	Total
			Level	Level	Level	Marks
I	Temperature Measurement techniques	16	4	12	5	21
II	Level Measurement Techniques	12	4	12	5	21
III	Temperature and level Transmitters	8	0	10	4	14
IV	Force And Torque Measurement Techniques	4	2	6	2	10
V	Vibration Measurement Techniques	2	0	2	2	4
	Total	**42**	**10**	**42**	**18**	**70**

***Legends:** R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)*

***Note:** This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.*

10. SUGGESTED LIST OF 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.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Take small instrumentation components to the class when teaching
ii. Massive open online courses (MOOCs) may be used to teach various topics/sub-topics.
iii. Internet based home assignments
iv. Mini project

v. About 20% of the topics/sub-topics which are relatively simpler or descriptive in nature is to be given to the students for self-learning, but to be assessed during different assessment methods.

vi. Guide students on how to address issues on environment and sustainability

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be individually undertaken to build up the skill and confidence in every student to become problem solver so that he/she contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop- based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit a micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a. Implement bimetallic thermometer with two different metals.
b. Prepare model for seeback effect.
c. Implement temperature switch.
d. Implement level switch
e. Prepare model for sight glass level measurement.
f. Verify law of homogeneous circuit.
g. Verify law of intermediate metal.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication
1	Process Measurement and Analysis	Liptak, B. G.	I.S.A
2	Industrial Instrumentation	Eckman, D. P.	Wiley Eastern Limited, New Delhi
3	Industrial Instrumentation	Singh, S.K.	Tata Mc Graw Hill, New Delhi
4	Mechanical Measurements	Kumar, D. S.	Metropolitan Book Company, New Delhi

5	Process Instrumentation and Control	Kulkarni, A.P.	Nirali Prakashan, Pune
6	Mechanical and Industrial measurements	Jain, R.K.	Khanna publication, New Delhi
7	Industrial Instrumentation	Krishnaswamy, K. and S. Vijayachitra,	New Age International Publication, New Delhi
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

14. List of Software/Learning Websites

i. www.nptel.com
ii. https://instrumentationtools.com
iii. https://www.vlab.co.in/participating-institute-coe-pune
iv. https://vlab.amrita.edu/?sub=1&brch=282&sim=1511&cnt=1
v. http://www.ni.com

15. PO-COMPETENCY-CO MAPPING

Semester IV	**Process Instrumentation-II (Course Code: 4341701)**						
	POs						
Competency & Course Outcomes	**PO 1 Basic & Discipline specific knowledge**	**PO 2 Problem Analysis**	**PO 3 Design/ develop-ment of solutions**	**PO 4 Engineering Tools, Experimen-tation & Testing**	**PO 5 Engineering practices for society, sustainability & environment**	**PO 6 Project Manage-ment**	**PO 7 Life-long learning**
Competency	**To develop skill for operating and testing various temperature, level, force, torque and vibration measuring instruments.**						
CO1: Apply principles behind the working of temperature and level sensors	2	-	-	-	2	-	

CO2: Select instrument for measurement of temperature and level.	2	2	-	3	-	3	
CO3: Use temperature and level transmitters.	-	2	2	3	-	--	2
CO4: Test temperature and level switches.	1	2	2	2	-	-	-
CO5: Select an instrument to measure Vibration, Force and Torque.	2	2	-	3	-	3	-

***Legend:** '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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