GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Process Instrumentation - I
(Course Code: 4331703)

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

1. RATIONALE

In the present industrial scenario, it is essential that diploma engineering students be able to identify, classify, troubleshoot and maintain the different process instrumentation. They are required to implement the planned process instrumentation. Therefore, this course has been designed so that students may learn to build, test and wire the different types of process instrumentation for Process Application.

2. COMPETENCY

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:

- **Identify, install, test, measure, calibrate and wire the different types of transducers and measuring equipments for Industrial Process Application.**

3 COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

- CO1: Identify the various instruments installed in actual process plants with regards to its functionality such as measurement, switching and transmission.
- CO2: Measure the magnitude of process parameter like Pressure, Flow, Speed, Humidity, Moisture etc in a given industrial application.
- CO3: Test sensors for measurement of the magnitude of process parameter like Pressure, Flow, Speed, Humidity and Moisture.
- CO4: Calibrate sensors for measurement of the magnitude of process parameter like Pressure, Flow, Speed, Humidity and Moisture.
- CO5: Draw schematic diagram of process instrumentation for Pressure, flow, speed, moisture / Humidity in a process plant.

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) that are the sub-components of the COs. Some of the PrOs marked '*' are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Unit No.	Practical Outcomes (PrOs) (Outcomes' in Psychomotor Domain)	Hrs. required
1.	I	Measure a given unknown pressure using U-tube Manometer.	02
2.	I	Measure a given unknown pressure using Well-type Manometer.	02
3.	I	Perform Pressure Measurement using C-type Bourdon Tube Pressure Gauge.	02
4.	I	Perform Pressure measurement using bellows type pressure Gauge.	02
5.	I	Perform Pressure Measurement using Diaphragm type Pressure Gauge.	02
6.	I	Test and calibrate a given pressure gauge using Dead Weight Tester.	02
7.	I	Perform Pressure Measurement using LVDT type pressure Transducer.	02
8.	I	Perform Pressure Measurement using Strain Gauge type Pressure Transducer.	02
9.	I	Perform Pressure Measurement using Piezoelectric type Pressure transducer	02
10.	I	Perform Pressure Measurement using Capacitance type Pressure Transducer.	02
11.	I	Identify electrical contact configurations used in pressure switches.	02
12.	I	Demonstrate the operation of pressure switch.	02
13.	II	Perform Flow Measurement using Orifice Plate.	02

14.	II	Perform Flow Measurement using Flow Nozzle.	02
15.	II	Perform Flow Measurement using Venturi Tube.	02
16.	II	Perform Flow Measurement using Pitot Tube.	02
17.	II	Perform Flow Measurement using Rota meter.	02
18.	II	Perform Flow Measurement using Magnetic Flow meter.	02
19.	II	Perform Flow Measurement using Vortex Flowmeter.	02
20.	II	Perform Flow Measurement using Turbine Flow meter.	02
21.	II	Perform Flow Measurement using ultrasonic Flow meter.	02
22.	III	Measure Speed using Mechanical Tachometer.	02
23.	III	Measure Speed using A.C. Tachometer.	02
24.	III	Measure Speed using D. C. Tachometer.	02
25.	III	Measure Speed using Magnetic Tachometer.	02
26.	III	Measure Speed using photoelectric	02
27.	III	Measure Speed using Stroboscope.	02
28.	IV	Perform Humidity Measurement using Hair Hygrometer.	02
29.	IV	Perform Humidity measurement using dry bulb and wet bulb	02
30.	IV	Perform Humidity Measurement using Thin Film Capacitance Hygrometer.	02
31.	IV	Perform Humidity Measurement using Electrolytic Hygrometer.	02
32.	IV	Perform Humidity measurement using Infrared Absorption Hygrometer.	02
33.	V	Test the pressure switch.	02
34.	V	Calibrate the pressure switch.	02
35.	V	Test the pressure transmitter.	02
36.	V	Calibrate the pressure transmitter.	02
37.	V	Test the Flow switch.	02
38.	V	Calibrate the Flow switch.	02
39.	V	Test the Flow transmitter.	02
40.	V	Calibrate the Flow transmitter.	02
		Total	80

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	Select instruments for practical performance	10
2	Prepare of experimental setup	15
3	Operate the equipment setup or circuit	15
4	Follow safe practices measures	10
5	Record observations correctly	20
6	Interpret the result and conclude	30
	Total	100

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's 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)	21-50,
2	DC power supply (-30 →0→+30 V with at least 1A current capacity)	All
3	Measuring equipment like CRO (preferably dual channel, 20Mhz)	All
4	Multi meter	All
5	Electrical tool kit.	All
6	Circuit/Trainer board/ Demonstration modules of Manometers	1-2
7	Bourdon tube C type, Twisted, Spiral Helical	3
8	Bellows Metallic and Non metallic	4
9	Diaphragm Disc, Flat, Corrugated	5
10	Pressure based Instrument calibration set up	6
11	Dead Weight Tester	6
12	Pressure Switches	11-12,32-33
13	Pressure Gauges bellows type, Bourdon tube type and Diaphragm type	3-5,
14	Strain Gauge type Pressure Transducer	8
15	Capacitance type Pressure Transducer	10
16	LVDT type Pressure Transducer	7
17	Electronic differential pressure transmitters	38-40

18	Pneumatic Differential pressure transmitter	38-40
19	Smart/Intelligent Pressure Transmitter	38-40
20	Pressure snubber of different type, overpressure protector	1-12,32-33,38-40
21	shut off valve, different type of siphon, chemical seal, fusible plug	1-12,32-33,38-40
22	Universal Calibrator	21-50
23	Different types of Flow Elements like Orifice, Venturi Tube, Flow Nozzle	13-15
24	Pitot tube flow trainer.	16
25	Rotameter	17
26	Magnetic Flow Meter	18
27	Turbine Flowmeter	19
28	Vortex Flowmeter	20
29	Ultrasonic Flow Meter	21
30	Flow Transmitters	46-48
31	Flow Switches.	43-45
32	Contact & Non-contact type Tachometers	22
33	A.C. Tachometer	23
34	D. C. Tachometer	24
35	Magnetic Tachometer	25
36	Photoelectric Tachometer	26
37	Stroboscopic Tachometer.	27
38	Hair Hygrometers	28
39	Wet & Dry Bulb Hygrometers.	29
40	Electrolytic Hygrometers.	31
41	Infrared Absorption Hygrometer.	32
42	Tachometer Calibration Set up	22-27
43	Flowmeter Calibration Set up	13-21
44	Hygrometer Calibration Set up	28-32
45	HART Calibrator	33

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 fulfill the development of this course competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical appliances.
c) Practice environmental 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.

COURSE DETAILS

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit - 1 Pressure Measurement Techniques	1a. State importance of pressure measurement in process industries. 1b. Enlist and define types of pressure. 1c. List out different pressure measuring units and show relations among them. 1c-1. Convert pressure from mmhg to atm, mmhg to bar, mmhg to pascal, psi to bar, bar to kg/cm2, kg/cm2 to psi 1d. Explain working principle and construction for various pressure measuring devices with neat sketch and also with its merits and demerits. (1.4 to 1.8). 1e. List applications for pressure devices (1.4 to 1.10). 1f. Describe pressure switch with sketch. 1g. Describe dead weight tester with sketch.	1.1. Pressure measurement. 1.1. Types of pressure: static, dynamic, absolute, differential, atmospheric, gauge pressure, vacuum. 1.3. Pressure units. 1.4.Manometers : U type, well type, inclined type, ring type, Float type, Barometer 1.5. Pressure sensing elements : Bellows, Diaphragm, Bourdon Tube, compound gauge 1.6.Electrical pressure sensors: - LVDT type, strain gauge, Piezo electric type, Capacitance type. 1.7. Optical type Pressure Transducer. 1.8.Vacuum sensors:-Thermal Conductivity gauge, Pirani Gauge, Ionization Gauge,

	1h. Explain Pressure Transmitter with neat sketch/block diagram. (1.11 to 1.12). 1i. List Pressure Accessories. (1.13)	McLeod's gauge. 1.9. Pressure switch. 1.10. Dead weight tester. 1.11. Pneumatic Differential pressure transmitter, Electronic differential pressure transmitters: - Capacitive and Strain Gauge type. 1.12. HART Pressure Transmitter. 1.13 Pressure accessories such as pressure snubber, overpressure protector, shut off valve, siphon, chemical seal.
Unit - 2 Flow Measurement Techniques	2a. State importance of flow measurement in process industries. 2b. Define terminology and characteristics for flow measurement (2.2) 2c. Define Reynolds's number. 2d. Enlist &define different types of Flow (Turbulent and Laminar flow) 2e. Derive Bernoulli's theorem with flow equation for compressible fluids. 2f. Explain pressure profile through orifice plate. 2g. Enlist units of flow measurement and explain conversion factors between them. 2h. Convert flow rate from Cubic Feet per Second (CFS) to Cubic Meters per Second (CMS) and from Liters per Minute (L/min) to Gallons per Minute (G/min). 2i. Classify flow measuring methods. 2j. Explain detail construction for Orifice plate, flow nozzle, Venturi tube. Pitot tube. 2k. Explain working principle and construction for target flow meter. 2l. Explain working principle with construction for various flow measuring devices (2.6 to 2.13). 2m. List out merits and demerits of flow measuring devices.(2.5 to 2.13). 2n. List out applications of flow measuring devices.(2.5 to 2.13)	2.1. Introduction to flow measurement. 2.2. Specific gravity, density, viscosity, compressibility, effect of pressure and temperature on flow measurement 2.3. Measurement of flow rate in closed pipe using Bernoulli's theorem. 2.4. Turbulent and Laminar Flow, Reynolds's number. 2.5.Differential Flow sensing elements: Orifice plate, flow nozzle, Venturi tube. Pitot tube, Target. 2.6.Variable area meter: Rotameter. 2.7.Magnetic flow meters. 2.8.Ultrasonic flow meters. 2.9.Turbine flow meter. 2.10.Thermal flow meter. 2.11.Vortex flow meter. 2.12.Mass flow meter. 2.13.Positive displacement meters: Piston cylinder type, Nutating disc, Rotating vane. 2.14.Flow switches. 2.15.Flow transmitters (Pneumatic and Electronic).

	2o. Enlist types of venturi tube. 2p. Enlist types of flow switch. for flow measurement.(liquid, gas) 2q. Explain working and construction of a flow switch. 2r. Explain Differential Pressure type flow Transmitter with neat sketch/block diagram. 2s. State need of Square root extractor in flow measurement.	
Unit - 3 Speed Measurement Techniques	3a. Define speed with units and classify it. 3b. List and explain speed measurement methods (3.2 to 3.5). 3c. List industrial application of tachometers.	3.1. Introduction to Speed measurement. 3.2. Mechanical tachometer: Revolution Counter, Resonance tachometer 3.3. Electrical tachometer: D.C. tachometer, A. C. tachometer, Magnetic drag(Eddy current) tachometer 3.4. Contactless Tachometer: Optical (photo electric) method, Magnetic Pickup method. 3.5. Stroboscopic tachometer.
Unit - 4 Moisture and Humidity Measurement Techniques	4a. Define Moisture and Humidity with units. 4b. Enlist terminology for humidity and define: relative humidity, absolute humidity, dew point, specific humidity, and hygrometer. 4c. Importance of moisture and humidity measurement in process industries. 4d. Explain different hygrometer with neat diagram (4.2 to 4.6).	4.1.Introduction to Moisture and Humidity. 4.2.Wet and dry bulb type hygrometer. 4.3. Hair hygrometer method 4.4. Thin film capacitance type hygrometer method. 4.5. Electrolytic hygrometer method 4.6. Infrared absorption hygrometer method.
Unit – 5 Instrument Selection and Calibration	5a. State selection criteria for Pressure measuring instruments. 5b. Calibrate pressure measuring instruments. 5c. State selection criteria for flow measuring instruments. 5d. Calibrate flow measuring instruments.	5.1 Selection criteria for pressure measuring instruments. 5.2 Calibration procedure of pressure measuring instruments. 5.3 Selection criteria for flow measuring instruments. 5.4 Calibration procedure of flow measuring instruments.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Pressure Measurement Techniques	**12**	**6**	**12**	**6**	**24**
II	Flow Measurement Techniques	**14**	**6**	**12**	**6**	**24**
III	Speed Measurement Techniques	**05**	**2**	**4**	**2**	**08**
IV	Moisture & Humidity Measurement Techniques	**05**	**2**	**4**	**2**	**08**
V	Instrument Selection and Calibration	**06**	**2**	**2**	**2**	**06**
	Total	**42**	**18**	**34**	**18**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from the above table.*

10. 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.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.

b) Guide student(s) in undertaking micro-projects.

c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.

d) 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 assesseduring different assessment methods.

e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

f) Guide students on how to address issues on environment and sustainability.

g) Guide students for reading manuals.

12. SUGGESTED MICRO-PROJECTS

- Small technical projects based on theory topic.

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in 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 s/he 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. Prepare orifice plate flowmeter
b. Prepare venturi flowmeter
c. Prepare nozzle flowmeter
d. Implement pressure switch
e. Prepare a chart or model which shows the detail of pressure, flow, Speed, Humidity/Moisture measuring instrument.

13. SUGGESTED LEARNING RESOURCES

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

6.	Mechanical and Industrial measurements	R.K. Jain	Khanna publication
7.	Industrial Instrumentation	K. Krishnaswamy & S. Vijayachitra,	New Age International
8.	Introduction to Measurements and Instrumentation	Arun K Ghosh	PHI
9.	Applied Instrumentation in Process Industries Vol-3a	William G Adrews	Gulf Publication Company
10	Instrumentation Reference Book 3rd Edition	Walt Boyes	Butterworth-Heinemann publications
11	Principle of Industrial Instrumentation 3rd Edition	D Patranabis	Mc Graw Hill
12	Industrial Instrumentation	D P Eckman	CBS publishers
13	Measurement Systems Application and Design	E O Doeblin D N Manik	Tata Mc Graw Hill
14	A Course in Electrical and Electronic Measurements and Instrumentation	A K Sawhney	DHANPAT RAI

14. SOFTWARE/LEARNING WEBSITES

- **http://en.wikipedia.org/wiki/Pressure_measurement**
- **http://www.ni.com/white-paper/13034/en/**
- **http://www.omega.com/literature/transactions/volume3/pressure.html**
- **http://en.wikipedia.org/wiki/Flow_measurement**
- **http://www.pc-education.mcmaster.ca/Instrumentation/flow.htm**

15. PO-COMPETENCY-CO MAPPING

Semester III	**PROCESS INSTRUMENTATION-1 (Course Code:** 4331703**)**						
	POs						
Competency & Course Outcomes	**PO 1** Basic & Discipline specific knowledge	**PO 2** Problem Analysis	**PO 3** Design/ development of solutions	**PO 4** Engineering Tools, Experimentation & Testing	**PO 5** Engineering practices for society, sustainability & environment	**PO 6** Project Management	**PO 7** Life-long learning

Competency :-	***Operate, Test and Calibrate Various Safety, Auxiliary and Control Components***						
CO1- Identify the various instruments installed in actual process plants with regards to its functionality such as measurement, switching and transmission.	2	-	-	-	-	-	-
CO2 - Measure the magnitude of process parameter like Pressure, Flow, Speed, Humidity, Moisture etc in a given industrial application.	2	3	1	-	-	1	-
C03 - Test sensors for measurement of the magnitude of process parameter like Pressure, Flow, Speed, Humidity, Moisture.	-	2	1	-	1	-	2
CO4- Calibrate sensors for measurement of the magnitude of process parameter like Pressure, Flow, Speed, Humidity, Moisture.	2	-	2	-	-	-	-
CO 5 - Draw schematic diagram of process instrumentation for Pressure, flow, speed, moisture / Humidity in a process plant.	1	2		3	-	-	-

*Legend: '**3**' for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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