GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Industrial Transducers
(Course Code: C4321701)

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

1. RATIONALE

Measurement of process parameters is an essential part of process. Transducers are used in almost every industry. Therefore, a diploma engineer in Instrumentation and Control Engineering is expected to understand the importance of measurement in process plants. Moreover, Skills of usage, installation, testing, maintenance and reasons of failure of the different type of transducers are necessary. The course is intended to develop the basic understanding as well as the competency for the same.

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

- **Appreciate the importance and different methods of measurement**
- **Cognize the working principle of different types of transducers.**

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:

a) Review Basic Concepts of Measurement (R)
b) Interpret Transducer requirements in Industries (U)
c) Paraphrase different sensor technologies (U)
d) Summarize techniques for representation of measurement data (U)
e) Diagnose failures of transducers (A)

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	2	4	30	70	25	25	150

(*):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

Following practical outcomes (PrOs) are the sub-components of the Course Outcomes (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.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Convert different measurement units into MKS, CGS form	1	02
2	Find out Relative Error , uncertainty while measuring AC voltage with Multimeter	1	02
Ref	https://www.webassign.net/question_assets/unccolphysmechl1/measurements/manual.html		
3	Develop a transducer with a potentiometer that will convert rotary input into 4-20mA of output (Use 24VDC as power supply)	1	02
4	Develop LDR based transducer which converts light intensity into detectable change current and also Plot graph of LDR resistance Vs. current output	1	02
5	Adjust Brightness of LED using Pot and measure intensity of light using LDR ,Plot a graph Rotary position vs current passing through LDR	1	02
6	Enlist process parameters and their measuring instruments in your process lab, Draw figure of any two process parameter measuring instruments	2	02
7	Set up a pressure measurement setup with a pressure gauge and a pressure transducer, tabulate and compare the data.	2	02
8	Build a MQ2 based Smoke Sensor to detect the environmental air quality change. Obtain the distance sensitivity after performing 5 different trials. (use buzzer to generate an alarm)	2	02
9	Build your own DIY thermocouple by joining two dissimilar metals. Set up an apparatus with two thermometers to measure the temperature change. Obtain the plot of temperature change vs voltage generated by your TC. Remove the thermometers and change the HOT junction temperature and find that temperature using the plot.	3	02
10	Test Archimedes principle using various weights and tabulate the difference in weight in air and weight submerged in water (use hook type scale)	3	02
11	Build a High level and Low level alarm system using buzzer (with various tunes) and HC SR 04	3	02
12	Measure level with any level transducer and compare that level transducer with sight glass scale.	3	02

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
13	Create and test the working of LVDT. Use copper wire as primary and secondary and metal road as core. Excite your primary by 12-0-12V transformer and check the output voltage.	3	02
14	Record Voice using mic as a transducer and obtain waveform of that recorded voice.	4	02
15	Display any transducer data on Electronic output displays	4	02
16	Build your own seismograph and demonstrate the concept of Mechanical chart recorders	4	02
Ref	https://www.scientificamerican.com/article/shaky-science-build-a-seismograph/		
17	Use a digital storage oscilloscope to display data obtained from transducer	4	02
18	Present a power point presentation of case study of any industrial tragedy	5	02
19	Build a DIY transducer which measures any one quantity and submit a **datasheet** of your DIY transducer **(Do not take readymade sensors)**	3	04
	Minimum 14 Practical Exercises		**28**

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. *Care must be taken in assigning and assessing study report as it is a first year study report. Study report, data collection and analysis report must be assigned in a group. Teacher has to discuss about type of data (which and why) before group start their market survey.*

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 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

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.	Multimeter, Voltage source, Current source, and Electronic workbench.	2,3,4,5
2.	Pressure transducer trainer kit.	7
3.	Ardunio Uno, MQ2 , LCD Screen , Misc Items	8
4.	Hook type Weight Scale Standard weights.	10
5.	Ardunio Uno, HC SR 04 Sensor , LCD Screen , Misc Items	11
6.	Level Measurement Probe / Kit	12
7.	Microphone and Oscilloscope	14
8.	DSO	17
9.	Strain gauge trainer kit, Standard weights.	15

Student must bring toolkit which must contain following items during LAB session:

Electrical Components	Breadboard, 1-10K Pot , Hookup wires, 12VDC adaptor, Female Barrel Jack, LEDs, LDR, Multimeter, Wire Stripper, Resistor Box, Diode, BC 547 Transistor, Soldering Ion, Soldering Wire, Flux, Electrical Insulation Tape, Teflon Tape, 9V battery (2), 9V battery connector, Push Button, 5V Buzzer, 5V DC motor, IR LED , IR Receiver, GPB (2) 12-0-12 Transformer, Tester, MQ 2 Smoke Sensor, piezo electric sensor, one solid copper wire, one solid aluminum/iron wire	1 Nos Each
Mechanical Tools	Plier, Nose Plier, Screw Driver Set, Portable Digital Weighing Scale (hook type), Measurement Tape,	1 Nos Each
Electronics (Optional)	Ardunio UNO , USB to USB B Cable , LM 35 , 741 Op amp , 555 timer, Push Buttons , 16x2 LCD Screen Blue, Ultra Sonic Sensor HC SR04, PIR Sensor, Relay Module, DHT 11/ DHT 22, IR Proximity	1 Nos Each

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 and procedure.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day to day observation.

e) 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

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Concepts of Measurement	1a. Recognize evolution of Measurement system; 1b. Discuss Methods of Measurement with example 1c. Explain different types of Units based on process parameter 1d. Enlist Fundamental and Derived Units 1e. Recall Different Unit Systems 1f. Convert different measurement units based on Prefixes 1g. Differentiate error and mistake 1h. Enlist and define errors during measurement 1i. Define Calibration; Explain use and need of calibration in with standards of measurement	1.1 History and evolution of Measurement system 1.1a. Indian Traditional ancient Measurement System v/s Existing Measurement System 1.1 Direct Method Indirect Method Comparative Method Substitution Method Null Method Fundamental Method 1.2 Units of Measurement ; Fundamental and Derived Units 1.3 MKS Units System, CGS Unit System and FPS Unit System ; Prefixes in Unit System 1.4 Conversions based on Prefixes and Different Unit System 1.5 Mistake and Error, systematic error Instrumental error, environmental error, random error.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		1.6 Calibration: Process standards, Working standards, Secondary reference standard, National Standard Organization
UNIT II Transducers in Industries	2.a. Infer Process without Transducer 2.b. Draw and Explain Block Diagram of Transducer 2.c. Explain the need of Industrial Transducer; 2.d. Narrate need of Electrical conversion in Transducer 2.e. Clarify the reason for 4-20mA standard signal. 2.f. Draw diagram of a Control Loop where Transducer is used in (i)Process parameter measurement (ii) Safety parameter measurement (iii) Environmental Parameters measurements 2.g. The Parameters while selection of transducer (i) Prepare a table to rank your most important parameters and value specifications.	2.1. Definition: Process, Sensor, transducer, transmitter 2.2. Block diagram of Transducer 2.3. Importance of Transducers in Process 2.4. Classify / Enlist different transducers based on parameters measured (Pressure , Temperature , Level and Flow) 2.5. Need of electrical parameters as a output of transducer ; 2.6. Standard range: 4-20mA 2.7. Draw diagram of a Control Loop where Process parameter measurement with an industrial example (CSTR) 2.8. Draw diagram of a Control Loop where Safety parameter measurement with an industrial example(Fire & Gas) 2.9. Draw diagram of a Control Loop

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		where Environmental parameter measurement with an industrial example(O2/CO: SOx/NOx) 2.10. Prepare a table to select relevant parameters, prioritize them, and then choose the appropriate value for the parameters.
Unit– III Sensor Technology	3a. State the working principles and laws based on which various parameters are being measured. 3b. Narrate the construction of given transducer 3c. Explain working principles of given transducer 3d. Enlist the application of given transducer	3.1. Mechanical Transducer: C-type Bourdon Type , Revolution Counter 3.2. Resistive Transducers : Strain Gauge, RTD 3.3. Capacitive Transducers: DPT and Capacitive Level gauge 3.4. Inductive Transducers: Faraday's Law of Electromagnetic Induction : LVDT, Electromagnetic Flow meter 3.5. Piezoelectric Effect : Pressure Transducer 3.6. See-back Effect : Thermocouple 3.7. Archimedes Principle : Displacer 3.8. Doppler Shift : Ultrasonic Flow Meter, Guided Wave Radar
Unit– IV	4.a. Explain Display methods of measured data	4.1 Display of measurement signals

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Transducer data Representation	4.b. Explain Recording methods of measured data 4.c. Explain Presentation methods of measured data 4.d Compare different Software for plant data monitoring	(i) Electronic output displays (ii) Computer monitor displays 4.2 Recording of measurement data (i) Mechanical chart recorders (ii) Magnetic tape recorders (iii) Digital recorders (iv) Storage oscilloscopes 4.3 Presentation of data (i) Tabular data presentation (ii) Graphical presentation of data
Unit– V Case Studies	5.a. Case studies of Transducer failure and its Implications 5.b. Explain the Incident caused by Transducer failure 5.c. Explain Root Cause analysis of Incident 5.d. Justify possibilities and Improvements after the failure	5.1. Transducer failure which caused massive fatalities 5.2. Transducer failure which caused massive environmental damages 5.3. Transducer failure which caused massive industrial / equipment damages

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A	Total Marks
I	Concepts of Measurement	8	7	5	2	14
II	Transducers in Industries	10	5	7	2	14
III	Sensor Technology	12	7	7	2	16

IV	Transducer data Representation	8	5	3	4	12
V	Case Studies	10	2	5	7	14
Total		**48**	**26**	**27**	**17**	**70**

Legend s: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

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 perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a) Prepare specification of some electrical, electronic components.
b) Give seminar on industrial instrumentation system.
c) Undertake a market survey of different electronic Sensors and Instruments.
d) Give seminar on advanced industrial instrumentation
e) Prepare the Charts that spread awareness on environmental effect due to industrial accidents.

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 assessed using 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

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-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit 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) Make a BC547 based level alarm system
b) Make LDR based switch and operate any on/off device.
c) Design an instrument to generate electricity using pizo-electric device.
d) Make a temperature sensitive on/off application.
e) Make an electronic level switch.
f) Model making of some innovative IoT projects.
g) Make a case study on any industrial accident.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Industrial Instrumentation and Control	S.K.Singh	Tata, McGraw-Hill, New Delhi ISBN: 9789351340102, 9789351340102
2	Measurements and Instrument principles	Allen Morris	ButterWorth Heinamann
3	Mechanical and Industrial Measurements (Process Instrumentation and Control)	R.K. Jain	Khanna Publishers New Delhi Latest Edition
4	Fundamentals of Industrial Instrumentation	William C Dunn	Tata, McGraw-Hill,New Delhi, Latest Edition

14. SOFTWARE/LEARNING WEBSITES

- For 2g: https://www.spaceagecontrol.com/selpt.htm
- For Case Study : USCSB YouTube Channel : https://www.youtube.com/channel/UCXIkr0SRTnZO4_QpZozvCCA
- https://nptel.ac.in/courses/108/105/108105064/

15. PO-COMPETENCY-CO MAPPING

Semester I	Industrial Transducers (Course Code: C4321701)						
	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	Test various electrical, electronic and pneumatic components and devices using relevant tools and instruments following safe work practices.						

Course Outcomes							
CO 1) Review Basic Concepts of Measurement	3	-	-	-	-	-	1
CO 2) Interpret Transducer requirements in Industries	2	-	2	1	1	-	1
CO 3) Discuss different sensor technologies	1	-	1	-	-	-	1
CO 4) Summarize techniques for representation of measurement data	1	-	1	-	-	-	-
CO 5) Diagnose failures of transducers	1	3	-	1	2	1	2

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

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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