Program Name : **Electrical Engineering Program Group / Diploma in Industrial Electronics**

Program Code : **EE/EP/EU/IE**

Semester : **Fourth**

Course Title : **Industrial Measurements**

Course Code : **22420**

1. RATIONALE

In industry, engineering diploma holders (also called technologists) are expected to handle basic instruments for the measurement of various process parameters such as temperature, pressure, flow and level in different types of industries. The technologists should be able to select proper instruments for the measurement of above parameters and also maintain these instruments for for proper functioning in different applications. This course has been therefore designed to develop this competency and related outcomes.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences.

- **Maintain different transducers used for measurement of various parameters.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Select the relevant transducers for measuring various parameters.
b) Maintain the different types of pressure transducers.
c) Maintain the different types of flow transducers.
d) Maintain the different types of level transducers.
e) Maintain the different types of temperature transducers.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment 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, **ESE** - End Semester Examination; **PA** - Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

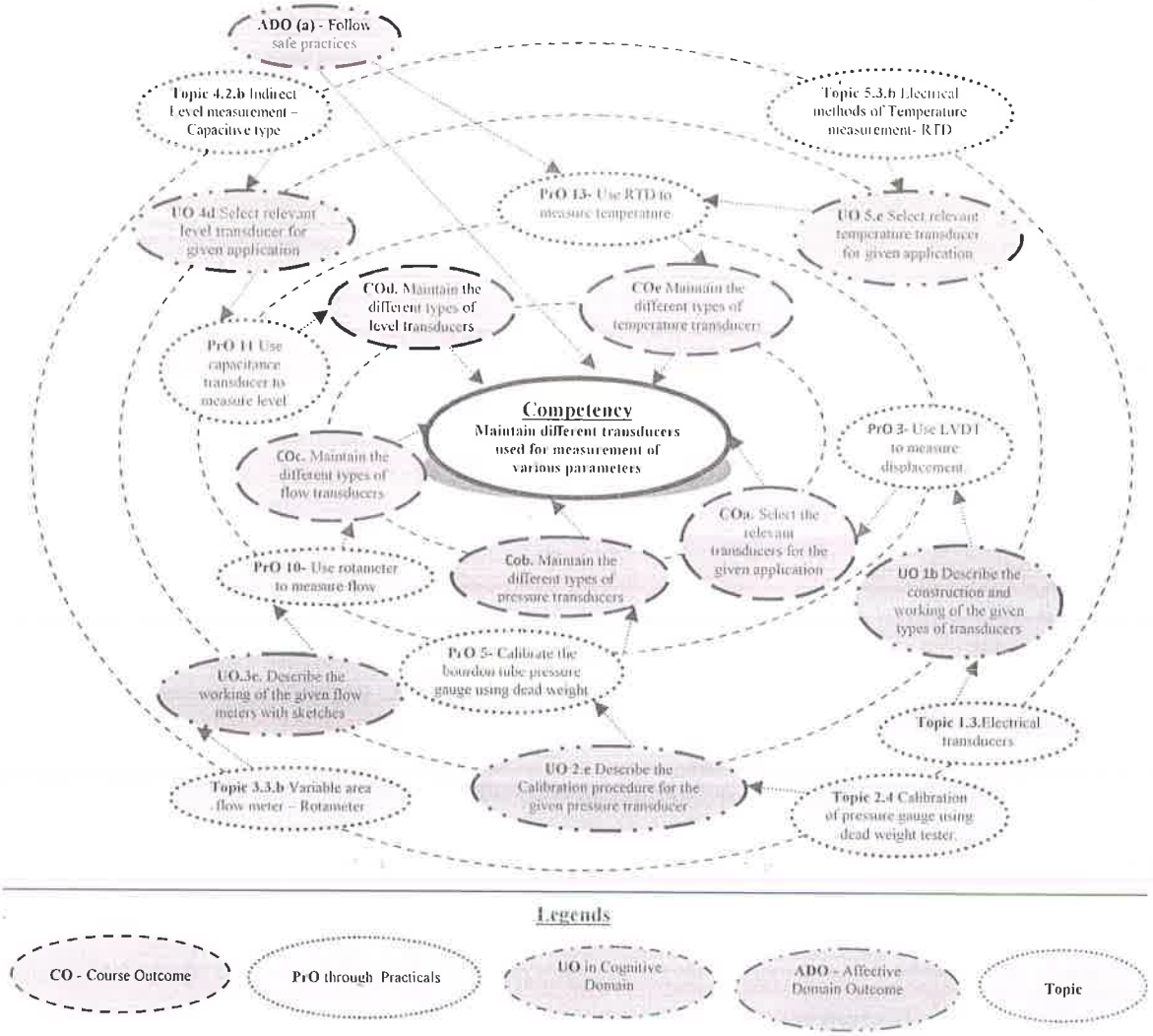

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use the potentiometer to measure the linear displacement	I	02*
2	Use the potentiometer to measure the angular displacement	I	02
3	Use LVDT to measure displacement.	I	02
4	Use the strain gauge to measure weights.	I	02
5	Use Bourdon tube pressure gauge to measure pressure	II	02*
6	Calibrate the bourdon tube pressure gauge using dead weight tester	II	02
7	Assemble/dismantle digital pressure measurement system	II	02
8	Use orifice meter for flow measurement	III	02*
9	Use venturimeter for flow measurement	III	02
10	Use rotameter for flow measurement	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
11	Use capacitance transducer to measure level	IV	02*
12	Use air purge method to measure level	IV	02
13	Use RTD to measure temperature	V	02*
14	Use Thermocouple to measure temperature	V	02
15	Calibrate RTD temperature measuring instruments	V	02
16	Calibrate Thermocouple temperature measuring instruments	V	02
	Total		**32**

Note

i. A suggestive list of **PrOs** *is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Preparation of experimental setup	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observation and recording	10
e.	Interpretation of result and conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will help in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Pro. S. No.
1	**LVDT trainer kit**- Displacement range +/- 20 mm. Accuracy of +/- 2% Primary Excitation 4 KHZ and 1 Volt. RMS Output : Digital display of +/- 20mm	3
2	**Strain gauge trainer kit**: Strain gages of 350 ohms. Accuracy: +/- 1% Power Supply 230 Vac. maximum of 5-kg load. Digital indication	4
3	**Bourdon tube pressure gauge**: Input pressure range 0 – 50 psi. Accuracy of +/- 2%. Dial gauge indication in the range 0 to 50 psi.	5
4	**Dead weight tester :** Input range 0-10 kg. Output on dial gauge 0 – 10kg/cm^2	6
5	**Orifice meter measurement setup:** 1''line size, concentric type. MOC-SS, U tube manometer 400 mm height, Range 0-1000LPH, Digital display	8
6	**Ventury flow measurement setup:** 1''line size, MOC-SS, U tube manometer 400 mm height. Range 0-1000LPH, Digital display	9
7	**Rotameter flow measurement setup:** Range 0-1000 LPH, Glass tube body, Bob Material-SS, connection 1'', Mounting inlet bottom top outlet.	10
8	**Capacitance level measurement:** Input range 0-500 mm, power supply 230 V ac , 2 wire capacitance type, top mounted, Digital display indication of 0 – 500mm.	11
9	**Air purge level measurement:** Level tank ,height 0-500mm ,air pressure regulator ¼" valve ,air compressor with ¼" connection and pressure gauge power supply 230 Vac, Level indication	12
10	**RTD temperature measurement:** Temp range 0-100 ^{0}C digital, temp bath, RTD Type pt100,accuracy +/- 1% , power supply 230v ac,	13
11	**Thermocouple temperature measurement:** Temp range 0-200^0 c, temp bath, Thermocouple K Type ,accuracy of +/- 1% , power supply 230v ac, digital indication of temp	14

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Applications of Transducers	1a. Describe with sketches function of the given components used in instrumentation system. 1b. Explain with sketches the construction and working of the given type (s) of transducer(s). 1c. Differentiate the working of the given types of transducers with sketches. 1d. Select relevant transducer for given application with justification. 1e. Prepare the specification of	1.1 Function of each block of Instrumentation system. 1.2 Transducer: Need, Classification - Active and Passive, Analog and Digital, Primary and Secondary, Mechanical and Electrical. 1.3 Electrical Transducers: Resistive transducers- Linear and Angular potentiometers, strain gauge, types, gauge factor. 1.4 Capacitive transducer. 1.5 Inductive transducer –LVDT, RVDT 1.6 Piezoelectric transducer, photo electric transducer-LDR, photo voltaic cell.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given transducer.	1.7 Selection criteria of transducers.
Unit– II Pressure measurement	2a. Describe with sketches the construction of the given type of pressure transducer. 2b. Explain with sketches the working of the given type of pressure transducer with sketches. 2c. Select the relevant pressure transducer for the given application with justification 2d. Describe with sketches the calibration procedure for the given pressure transducer. 2e. Prepare the specification of the given pressure transducer. 2f. Describe with sketches the procedure to troubleshoot the given type of pressure transducer.	2.1 Pressure and its units, Types - Absolute, Gauge, Atmospheric, Vacuum. 2.2 Classification of Pressure measuring devices: a. Manometer-U tube, Inclined Tube, Well type manometer b. Elastic pressure transducer: Bourdon Tube Bellows, Diaphragm, Capsule c. Electrical pressure transducers: Bourdon tube with LVDT, Bellow with LVDT Diaphragm with Strain gauge. 2.3 Specification of electrical pressure transducer. 2.4 Calibration of pressure gauge using dead weight tester.
Unit– III Flow measurement	3a. Describe with sketches the construction of the given type of flow transducer with sketches. 3b. Explain with sketches the working of the given type of flow transducer with sketches. 3c. Differentiate the salient features of the given type of flow transducers. 3d. Select relevant flow transducer for the given application with justification. 3e. Prepare the specification of given flow transducer. 3f. Describe with sketches the procedure to troubleshoot the given type of flow transducer.	3.1 Flow and its units, Types of Flow – Laminar, turbulent, Reynolds number 3.2 Classification of flow measuring transducers: a. Variable head flow meter: Venturimeter, orifice plate meter, flow nozzle, pitot tube b. Variable area flow meter – Rotameter c. Electrical flow meter: Turbine flow meter, Electromagnetic Flow meter, Ultrasonic flow meter- Time difference and Doppler Type, Hot wire anemometer, Vortex flow meter 3.3 Positive displacement meter-nutating disc type. 3.4 Typical specifications of various flow meters.
Unit-IV Level measurement	4a. Describe with sketches the construction of the given type of level transducer. 4b. Explain with sketches the working of the given type of level transducer. 4c. Different the salient features of the given type of level	4.1 Level and its units, Classification of level measurement methods: a. Direct methods- Hook type, Sight glass, Hydrostatic type (air purge). b. Indirect measurement method: Float type with linear and rotary potentiometer, Capacitive type Ultrasonic type, Nuclear Radiation

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	transducers. 4d. Select relevant level transducer for the given application with justification. 4e. Describe with sketches the calibration procedure for the given type of level transducer. 4f. Prepare the specification of given level transducer. 4g. Describe with sketches the procedure to troubleshoot the given type of level transducer.	type, Radar type. 4.2 Typical specifications of electrical level measurement methods. 4.3 Calibration of Air purge and Capacitance type level system.
Unit –V Temperature measurements	5a. Describe with sketches the construction of the given type of temperature transducer. 5b. Explain with sketches the working of the given type of temperature transducer. 5c. Differentiate the salient features of the given types of temperature transducers. 5d. Select relevant temperature transducer for the given application with justification. 5e. Describe the calibration procedure of temperature measuring system with inputs from RTD and thermocouple. 5f. Prepare the specification of given temperature transducer. 5g. Describe with sketches the procedure to troubleshoot the given type of temperature transducer.	5.1 Temperature and its Units, temperature scales and conversions. 5.2 Classification of temperature measuring transducers: a. Filled system thermometer- vapour pressure thermometer. b. Expansion thermometer-Bimetallic thermometer. 5.3 Electrical methods- a. Thermistors, b. RTD – (PT-100, 2 /3 wire) c. Thermocouple – Law of intermediate temp and intermediate metals Seebeck and Peltier effect, Types J, K, R, S, T 5.4 Pyrometer – Optical method, Radiation method. 5.5 Typical specifications of Thermistor, RTD and Thermocouple. 5.6 Calibration of temperature measuring transducers.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Applications of transducers	8	02	04	06	12

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
II	Pressure Measurement	10	02	04	08	14
III	Flow Measurement	12	02	04	10	16
IV	Level Measurement	8	02	04	08	14
V	Temperature Measurement	10	02	04	08	14
Total		**48**	**10**	**20**	**40**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from 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. Prepare charts for measurement system using temperature, pressure, flow, level system.
b. Prepare broad specifications for basic transducers of temperature, level, pressure and flow.
c. Market survey for procurement of above transducers in point 'b'.
d. Prepare installation sketches of above transducers in point 'b'.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Arrange visit to process industries and calibration workshops.
f. Use teaching aids such as videos/ YouTube of process industries.
g. Arrange expert lectures of industry person.
h. In respect of item 10 above, teachers need to ensure to create opportunities and provisions for such co-curricular activities.
i. Instruct students to safety concern of handling various transducers.

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-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 dated work diary consisting of individual contribution 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 micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Use RTD for indication of temperature.
b. Use Thermistor for indication of temperature.
c. Use level transducer for indicating and controlling the level of water tank.
d. Use float type level sensor for indication of level of water tank.
e. Use pressure transducer for indicating and controlling the compressor utility system.
f. Use strain gauge for weight measurement in simple platform.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Electrical and Electronic Measurements and Instrumentation	Sawhney, A.K.	Dhanpat Rai and Sons, N. Delhi 201; ISBN:9788177001006
2	Industrial Instrumentation and Control	Singh, S.K.	McGraw Hill Publishing; N. Delhi 2010; ISBN:9780070678200
3	Principles of Industrial Instrumentation	Patranabis, D.	McGraw Hill Publishing Co. Ltd; N. Delhi 2010; ISBN:9780070699717
4	Instrumentation Systems and Devices	Rangan,C.S; Sharma, G. R ; Mani,S.V.	McGraw Hill Publishing; N. Delhi 2011; ISBN:9780074633502
5	Process Measurement Instrument Engineers Handbook	Liptak,B.G.	Chilton Book Co. U.S.A 1970 ISBN:9780750622547
6	Instrumentation, measurement and analysis	Nakra,B.C; Choudhry, K.K.	McGraw Hill Publishing; N. Delhi 2015; ISBN:9780070151277

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.nptel.ac.in/courses/108105064/#
b. www.engineeringtoolbox.com/flow-meters-d_493
c. www.instrumentationtools.com/category/level-measurement/
d. www.web.mst.edu/~cottrell/ME240/Resources/Temperature/Temperature.pdf
e. www.instrumentationtools.com/how-rtd-measuring-the-temperature/
f. www.instrumentationtools.com/category/pressure-measurement/
g. www.electronics-tutorials.ws/io/io_3.html
h. www.isa.org

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