GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Electrical Instrumentation
(Course Code: 4330902)

Diploma programmer in which this course is offered	Semester in which offered
Electrical Engineering	Third

1. RATIONALE

Precise measurement of the quantities such as voltage, current, power, temperature, pressure etc. is essential to operate and maintain the electrical machines and systems effectively and efficiently. Transducers and instruments are the devices which are used to measure such parameters. The electrical diploma engineer should therefore be competent to use, calibrate and maintain different types of electrical instrumentation systems and transducers used in the industry and power systems. This demands a better understanding of the construction, material used and principle of operation of various types of measuring instruments. This course is therefore designed to meet these needs and hence it is a core course for any electrical engineer.

2. COMPETENCY

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

- **Use relevant measuring instrument in different electrical applications.**

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) Interpret different terms related to measurement and instrumentation
b) Measure circuit parameters using potentiometers and DC and AC bridges.
c) Use electromechanical instruments for measurement of electrical quantities.
d) Calibrate ammeter, voltmeter, wattmeter and energy meter as per IS.
e) Use transducers to measure various non-electrical quantities.

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	
4	0	2	5	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

The 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	Identify measuring instruments on the basis of symbols on dial, type, accuracy, class, position and scale.	I	2*
2	Measure medium resistance using Wheatstone bridge.	II	2*
3	Measure low resistance using Kelvin's double bridge.	II	2*
4	Measure inductance by using Universal Impedance bridge.	II	2*
5	Measure capacitance by using Universal Impedance bridge.	II	2
6	Measure insulation resistance of winding insulation by using Megger.	II	2*
7	Measure earth resistance by using earth tester.	II	2
8	Measure power drawn by three phase load using two wattmeter method.	III	2*
9	Measure different electrical parameters using clip on meter.	III	2*
10	Test phase sequence of three phase AC supply using phase sequence indicator.	III	2
11	Measure maximum demand using Maximum demand meter.	III	2
12	Use Tri-vector meter for measuring kW, kVAr and kVA of a power line.	III	2
13	Extend the range of ammeter and voltmeter by using CT and PT.	III	4
14	Calibrate Ammeter (MI/MC) as per IS.	IV	2*
15	Calibrate Voltmeter (MI/MC) as per IS.	IV	2*
16	Calibrate Single phase energy meter as per IS.	IV	2*
17	Calibrate single phase wattmeter using standard voltmeter and ammeter.	IV	2
18	Calibrate power factor meter as per IS.	IV	2
19	Measure Linear displacement using LVDT.	V	2*
20	Use Thermocouple to control the temperature of a furnace/machine.	V	2
21	Measure speed using inductive pick-up transducer.	V	2
22	Use Strain gauge to measure strain.	V	2*
	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. *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	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices.	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 user in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO.No.
1	Wheatstone bridge (Measuring Range- 1.000Ω to 10.00MΩ)	2
2	Kelvin's double bridge (0.2 Micro - Ohms to 11 ohms)	3
3	Universal Impedance bridge (Basic accuracy- 0.3%)	4,5
4	Megger (dc voltage generated 500 V, 1000 V)	6
5	Earth tester	7
6	Two element wattmeter 0-1000W(5/10A,300/600V)	1,8,17
7	Clip on meter :Analog and digital meters with latest specifications	9
8	Phase sequence indicator: Analog and digital meters with latest specifications	10
9	Maximum demand meter	11
10	Tri vector meter	12
11	Current transformer and Potential transformer	13
12	Ammeter MI/MC (0-1 A, 0-5 A, 0-10 A)	1,13,14,17
13	Voltmeter MI/MC (0-50 V,0-150 V,0-300 V,0-500 V)	1,13,14,17
14	Energy meter : 1Ø and 3Ø analog and digital meters with latest specifications	16
15	Power factor meter : Analog and digital meters with latest specifications	18
16	LVDT : +12V D.C. at 50mA D.C .regulated Power Supply	19
17	Thermocouple	20
18	Inductive pick-up transducer	21
19	Strain gauge: +12V D.C. at 50mA I.C. regulated Power Supply	22

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(while doing a micro-project)
b) Follow safety practices while using AC supply and electrical equipments.
c) Work as a group member (while performing experiments and taking readings)
d) 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 Fundamentals of measurement & instrumentation	1a.Differentiate between direct and indirect measurement 1b.Discriminate between Indicating, integrating and recording, absolute and secondary instrument 1c.Differentiate between deflecting, controlling and damping torques 1d.Explain different terms related to measurement 1e.Differentiate between different types of errors with examples	1.1 Methods of measurement -Direct and indirect methods 1.2 Types of Instruments - Indicating, integrating and recording, absolute and secondary instrument 1.3 Deflecting, Controlling and damping torques 1.4 Range, true value, indicated value, correction, sensitivity, repeatability, reproducibility, precision, Accuracy, significant figure, etc. 1.5 Types and sources of error : gross error, systematic error , random error
Unit – II Potentiometers and Bridges	2a.Explain the working of the DC potentiometer. 2b.Differentiate between different types of potentiometers 2c.Classify different types of resistances	2.1 Construction and working of DC potentiometer, and its applications 2.2 Dial type and Crompton type.. 2.3 Low, medium, and high resistance 2.4 Kelvin's double bridge, 2.5 Medium resistance by Wheatstone

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	2d. Explain the procedure to measure low resistance by Kelvin's double bridge with sketches 2e. Explain the procedure to measure medium resistances by Wheatstone's bridge and other methods with sketches. 2f. Justify the need of a Megger. 2g. Justify the need of a earth tester. 2h. Select an A.C. bridge to determine Inductance and capacitance.	bridge, Ammeter-voltmeter method, Ohmmeter. 2.6 High resistance by Mugger 2.7 Earth resistance by Earth tester. 2.8 Measurement of inductance and capacitance by Universal impedance bridge, A.C. bridge - Maxwell, Anderson, Hays, DeSauty's and Wien's bridge. (no phasor diagram)
Unit – III Electromechanical Instruments	3a. List the common errors in various electromechanical measuring instruments. 3b. Differentiate between moving iron and PMMC instruments 3c. Distinguish between electrodynamometer type and induction type meters. 3d. Describe the working of a hot wire instruments 3e. Select different types of electro-mechanical instruments for different kinds of measurement. 3f. Illustrate the use of shunt and multipliers for range extension of ammeters and voltmeters 3g. Illustrate the use of Current Transformer and Potential Transformer for range extension of meters	3.1 Common errors in electromechanical instruments 3.2 Moving iron instruments: Ammeter, voltmeter, Frequency meter, 3.3 PMMC instruments: ammeter, voltmeter, Vibration galvanometer. 3.4 Electrodynamometer type meter: ammeter, voltmeter, wattmeter, power factor meter. 3.5 Induction type Energy meter (single phase, three phase) 3.6 Hot wire type instruments 3.7 Tri vector meter, Maximum demand meter, Phase sequence indicator, Solid state energy meter, Clip on meter 3.8 Extension of range using shunt, multipliers and derive equation for them. 3.9 Extension of range of meters using instrument transformer like CT and PT
Unit – IV Calibration and Testing	4a. Justify the necessity of calibration 4b. State the procedure to calibrate various electrical instruments	4.1 Calibration and its importance 4.2 Calibration of ammeter, voltmeter and wattmeter and single phase energy meter(along with adjustments) as per IS

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – V **Transducers**	5a.State the basic requirements of transducers 5b. Classify different types of transducers 5c. Describe working principle of different types of electrical transducers. 5d. Describe working principle of different types of electro optical transducers. 5e.Explain the Incident caused by Transducer failure. 5f.Justify possibilities and improvements after the failure.	5.1 Basic requirements of transducers. 5.2 Classification based on : Transduction phenomenon, type of application, types of input and output signal, electrical principle involved. 5.3 Resistive Transducers, Inductive Transducers: LVDT, RVDT, Capacitive Transducers, Piezoelectric Transducers, Strain Gauge Transducers (unbonded and bonded), Thermocouple, RTD, Thermistor and semiconductor sensors 5.4 Opto-electronic devices: Photo emissive cells, Photoconductive cells, Photodiode, Photo transistor, Photovoltaic cells, Photo optic transducer. 5.5 Transducer failure which caused massive industrial / equipment damages and environmental damages.

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	Fundamentals of measurement and instrumentation	06	04	04	01	**09**
II	Potentiometers and Bridges	12	04	07	05	**16**
III	Electromechanical Instruments	16	07	08	05	**20**
IV	Calibration and Testing	04	01	02	01	**04**
V	Transducers	18	06	07	08	**21**
Total		**56**	**22**	**28**	**20**	**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 to 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 slightly 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 perform following activities in group (or individual) 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) Present chart showing real-life examples indicating various types of electrical measuring equipment.
b) Prepare PowerPoint presentation for different types of electromechanical instruments.
c) Solve numerical related to Bridges.

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) Show animation/ video to explain concepts, facts and applications related to electrical measuring instruments.
e) In respect of section no.10, teachers need to ensure to create opportunities and provisions for such co-curricular activities. (Use remaining practical hours).
f) Co-relating the importance of content of this course with other courses/ practical applications. (e.g. importance of a content in course or whole course related to A.C. Machines, Transmission and Distribution of Electrical Power, Energy Conservation Switchgear and Protection etc. and in practical industrial &/ domestic applications.)
g) Introduce E-waste recycling technology among the students.
h) 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 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) Prepare a report on various measuring instruments used in Instrumentation laboratory.
b) Build a model to extend the range of ammeter with the help of shunt resistor.

c) Build a model to extend the range of voltmeter with the help of high resistor (multiplier).
d) Build a model of phase sequence indicator.
e) Prepare a report on transducers or sensors used in automation and robotics.
f) Design an instrument to generate electricity using piezoelectric device.
g) Case studies on transducer failure and its implications.
h) Make a case study on any industrial accident.
i) Prepare charts that spread awareness on environmental effect due to industrial accidents.
j) Compile the reports of past industrial/massive accidents, their causes, effect and strategies used and suggestion to prevent such incidents and present the same in seminar.
k) Prepare a chart that classifies recycling process for electronic waste and plastics.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	A text book of Electrical Technology Volume-I (Basic Electrical Engineering)	B. L. Theraja& A.K. Theraja	S. Chand and Co., New Delhi, 23 edition or Latest edition (ISBN : 9788121924405)
2	Principles of Electrical Engineering	B. R. Gupta	S. K. Kataria& Sons, New Delhi, Latest edition (ISBN-9788121901031)
3	Fundamentals of Electrical Engineering	Tarlok Singh	S. K. Katariav& Sons, New Delhi, Latest edition(ISBN: 9789350140680)
4	Basic Electrical Engineering	K. Uma Rao and A. Jayalakshmi	Pearson Education, New Delhi Latest Edition(ISBN: 9789385909283)
5	Basic Electrical and Electronics Engineering	Ravish. R. Singh	Tata McGraw Hill EducationPvt.Ltd., New Delhi 2018 edition or Latest edition (ISBN-978007026092)
6	Fundamentals of Electrical Engineering and Electronics	S.K. Sahdev	Dhanpatrai& Co., New Delhi Latest edition(ISBN: 978877002027)
7	Principles of Electrical Engineering and Electronics	V.K. Mehta Rohit Mehta	S. Chand and Co., New Delhi (ISBN : 9789352837199)

14. SOFTWARE/LEARNING WEBSITES

WEBSITES

- https://nptel.ac.in/courses/108105153
- https://nptel.ac.in/courses/108105064
- https://lectures.gtu.ac.in/listview.aspx?br=09&course=DI

- https://circuitglobe.com/category/electrical-terms/electrical-instrumentation
- https://www.electrical4u.com/electrical-engineering-articles/measurement/
- https://www.electricaltechnology.org/
- https://vp-dei.vlabs.ac.in/Dreamweaver/measurement.html

15. PO-COMPETENCY-CO MAPPING:

Semester III	Electrical Instrumentation (Course Code:4330902)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solution	PO4 Engineering Tools, Experimen-tation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Use relevant measuring instrument in different electrical applications.**						
Course Outcomes CO1 Interpret different terms related to measurement and instrumentation	3	-	-	2	-	-	-
CO2 Measure circuit parameters using potentiometers and DC and AC bridges.	2	2	2	3	-	-	-
CO3 Use electromechanical instruments for measurement of electrical quantities.	2	-	-	3	-	-	-
CO4 Calibrate ammeter, voltmeter, wattmeter and energy meter as per IS.	3	2	2	3	-	-	-
CO5 Use transducers to measure various non electrical quantities.	2	2	2	3	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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