GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

Course Curriculum

ELECTRICAL INSTRUMENTATION
(Code: 3330903)

Diploma Programme in which this course is offered	Semester in which offered
Electrical Engineering	3rd semester

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 (Programme Outcome according to NBA Terminology):

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

- **Maintain different types of electrical instrumentation systems and transducers.**

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
04	00	02	06	70	30	20	30	150

Legends: L - Lecture; **T -** Tutorial/Teacher Guided Student Activity; **P -** Practical; **C -** Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

4. COURSE DETAILS

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	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	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
	1a. Explain different terms related to measurement	1.4 Range, true value, indicated value, correction, sensitivity, repeatability, reproducibility, precision, Accuracy, significant figure, etc.
	1b. Differentiate between different types of errors with examples	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	2.1 Construction and working of DC potentiometer, and its applications 2.2 Dial type and Crompton type.
	2c. Classify different types of resistances 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.	2.3 Low, medium, and high resistance 2.4 Kelvin's double bridge, 2.5 Medium resistance by Wheatstone bridge, Ammeter-voltmeter method, Ohmmeter,
	2a. Justify the need of a Megger 2b. Justify the need of a earth tester.	2.6 High resistance by Mugger, 2.7 Earth resistance by Earth tester.
	2c. Select an A.C. bridge to determine Inductance and capacitance	2.8 Measurement of inductance and capacitance by Universal impedance bridge, A.C. bridge - Maxwell, Anderson, Hays, Desauty 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	3.1 Common errors in electromechanical instruments 3.2 Moving iron instruments: Ammeter, voltmeter, 3.3 PMMC instruments: ammeter, voltmeter, Vibration galvanometer. 3.4 Electrodynamometer type meter: ammeter, voltmeter, wattmeter, power

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
	3d. Describe the working of a hot wire instruments	factor meter. 3.5 Induction type Energy meter (single phase, three phase) 3.6 Hot wire type 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	3.7 Frequency meter, 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	4.1 Calibration and its importance.
	4b. State the procedure to calibrate various electrical instruments	4.2 Calibration of ammeter, voltmeter and wattmeter and single phase energy meter(along with adjustments) as per IS
Unit – V Transducers	5a. State the basic requirements of transducers 5b. Classify different types of transducers.	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.
	5c. Describe working principle of different types of electrical transducers	5.1 Resistive Transducers, Inductive Transducers: LVDT, RVDT, Capacitive Transducers, Piezoelectric Transducers, Strain Gauge Transducers (unbonded and bonded), Thermocouple, RTD, Thermistor and semiconductor sensors
	5d. Describe working principle of different types of electro optical transducers	5.2 Opto-electronic devices: Photo emissive cells, Photoconductive cells, Photodiode, Photo transistor, Photovoltaic cells, Photo optic transducer

5. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	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	10	04	07	03	14
III	Electromechanical Instruments	16	07	08	06	21
IV	Calibration and Testing	06	01	02	02	05
V	Transducers	18	06	07	08	21
Total		**56**	**22**	**28**	**20**	**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.

6. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course Outcomes in psychomotor domain)** so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance.

Note: Here only Course Outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in affective domain** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Unit No.	Practical/Exercise (Course Outcomes in Psychomotor Domain according to NBA Terminology)	Apprx. Hrs. Required
1	II	Test the medium resistance using Wheatstone bridge	2
2	II	Test the low resistance using Kelvin bridge	2
3	II	Test the inductance by using Universal Impedance bridge	2
4	II	Test the capacitance by using Universal Impedance bridge	2
5	II	Use DC ammeter and voltmeter for different ranges	4
6	II	Use Moving Iron voltmeter and ammeter for different ranges	4
7	II	Measure maximum demand using Maximum demand meter	2
8	II	Find resistance of winding insulation by using Megger	2
9	III	Calibrate Ammeter(MI/MC) as per IS	2
10	III	Calibrate Voltmeter(MI/MC) as per IS	2
11	III	Calibrate Single phase energy meter as per IS	2
12	III	Measure different electrical parameters using clip on meter.	2
13	V	Measure Linear displacement using LVDT.	2
14	V	Use Thermocouple to control the temperature of a furnace/machine.	2
15	V	Test the Automatic Control of speed control for D.C. motor using tachogenerator	2

S. No.	Unit No.	Practical/Exercise (Course Outcomes in Psychomotor Domain according to NBA Terminology)	Apprx. Hrs. Required
16	V	Test the strain using strain gauge.	2
17	VI	Test Power and Power factor(using power factor meter) using two wattmeter method for three phase circuits	4
		Total	**36**

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare charts for understanding various electro-mechanical instruments
ii. Seminar by students on working of various instruments
iii. Prepare a survey report for various latest measuring instruments available in market
iv. Prepare a survey report to know the ratings of current transformer and potential transformer used in substation/industries

8. SPECIAL INSTRUCTION STRATEGIES (If Any)

i. Students should be shown animations/video films to explain the working concept of different transducers and instruments.
ii. Students should be taken to nearby industries/substations where different type of transducers and instruments are installed and they should be asked to observe their specifications including their range and least count etc. They should be encouraged to discuss with operators about what type of errors they encounter in these instruments and how they are eliminated and how instruments are maintained and calibrated?

9. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Books	Author	Publication
1.	Electrical and electronic instruments	Sawhney, A .K .	Dhanpat Rai Publications, New Delhi, 2010
2.	Electrical Measurements: fundamentals, concepts, applications	Reissland, M.U.	New Age International publishers, New Delhi, 2008
3.	A course in electronics & electrical measurement & instrumentation	Gupta ,J.B.	S.K. Kataria and Sons, New Delhi, 2011
4.	Principles of measurement & Instrumentation	Morris ,Alan. S	PHI publication, New Delhi, 2011
5.	Electrical Instrumentation	Bakshi, U.A., Bakshi A.V.	Technical Publication, Pune,2009
6.	Mechanical and industrial measurements ,	Jain ,R.K.	Khanna Publication, New Delhi, 2010
7.	Electrical Measurements and measuring instruments	Golding, E.W., Widdis, F.C.	Reem publications New Delhi, 2011
8.	Electronic Measurements and Instrumentation	K. Lal Kishore	Pearson, New Delhi, 2011

B) List of Major Equipment/Materials with Broad Specification

i. DC potentiometer : 0 - 1.1V D.C, TEST TERMINALS, COARSE & FINE adjustment
ii. Wheatstone bridge : Measuring Range- 1.000Ω to 10.00MΩ, Measuring Arm- x 1mΩ, x 10Ω + 10Ω x 10 + 100Ω x 10 + 1000Ω x10 (min. one step: 1Ω), **Ratio Arms-** x 0.001 x 0.01, x 0.01, x 0.1, x 1, x 10, 100, x 1000 (M10, M100, M1000 Murray & Varley loop testing), **Galvanometer Power Source** -Three 1.5V batteries (built-in), Range, ±0.1% of reading on 100Ω to 100kΩ Range, **Accuracy-** ±0.3% of reading on 10Ω to 1MΩ Range, ±0.6% of reading on 1Ω to 10MΩ Range
iii. Kelvin double bridge : Range : 0.2 Micro - Ohms to 11 ohms, Accuracy : 0.1% (or ±1 Slide wire division whichever is greater), Multiplier : 5 Ranges (0.01, 0.1, 1, 10 & 100)
iv. Weins bridge: Biasing Voltage : +12V, -12V DC etc..
v. Universal impedance bridge: Basic accuracy- 0.3%, Versatile , portable , compact LCR Meter for L-Q , C-D , R-Q, |Z|-Q measurements, Measurement frequencies 100 Hz, 120 Hz and 1 kHz
vi. LCR meter : Basic accuracy- 0.3%, Versatile , portable , compact LCR Meter for L-Q, C-D , R-Q, |Z|-Q measurements, Measurement frequencies 100 Hz, 120 Hz and 1 kHz
vii. Energy meter : 1Ø and 3Ø analog and digital meters with latest specifications
viii. Power factor meter : Analog and digital meters with latest specifications
ix. Trivector meter : With latest specifications
x. Two element wattmeter : With latest specifications
xi. Three phase power factor meter : Analog and digital meters with latest specifications
xii. Megger : Mains / battery pack operated (Capable of continuous duty for P.I. measurement of large Generators) analog/digital insulation tester with selectable ranges of 50V, 250V, 500 V, 1000 V, 2500 V , 5000 V.
xiii. Phase sequence indicator: Analog and digital meters with latest specifications
xiv. Clip on meter : Analog and digital meters with latest specifications With true-rms ac voltage and current measurements, the Fluke 373 Clamp Meter reads up to 600 A ac and 600 V ac or dc.
xv. Current transformer and Potential transformer
xvi. Decade resistance box: Accuracy: ± 1%, Max. D.C. voltage : 400 volts, jack-topped binding posts are used as output terminals
xvii. Range extension board : +12V D.C. at 50mA I.C.regulated Power Supply for Sine wave Oscillator
xviii. Shunts with ammeters: Accuracy: ± 1%, Measuring Range in ohms like - x 0.001 x 0.01, x 0.01, x 0.1, x 1, x 10, 100, x 1000
xix. Linear variable differential transducer : ±12V D.C. at 50mA I.C.regulated Power Supply for Sine wave Oscillator
xx. Strain gauge: ±12V D.C. at 50mA I.C.regulated Power Supply for Sine wave Oscillator
xxi. Thermo-couple : Types B, E, J, K, R, S, T and C thermocouples
xxii. Thermistor :as per standard specification and latest configurations
xxiii. PH meter:
xxiv. Multiple transducer kit: Inbuilt power supply, measurement facility, expansion facility and with latest features like computer interface etc.

C) List of Software/Learning Websites

i. Electronics work bench
ii. www.scientechworld.com
iii. www.ni.com/labview/
iv. www.scientificindia.com/home/scientificindia.asp
v. http://electricalandelectronics.org/
vi. www.electrical-electronics.co.in/

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. S.S. Mehta**, Sr. Lecturer, Electrical Engineering Department, B&B Institute of Technology,Vallabhvidyanagar.
- **Prof (Ms.).V.R. Kotdawala**, Sr. Lecturer, Electrical Engineering Department, Govt. Polytechnic, Himmatnagar.
- **Prof. A.A. Parmar**, Sr. Lecturer, Electrical Engineering Department, B&B Institute of Technology,Vallabhvidyanagar
- **Prof. J.K. Rathod**, HOD, Electrical Engg. Dept., Tolani F.G. Polytechnic, Adipur

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering
- **Dr. (Mrs.) C.S. Rajeshwari**, Professor & Head, Department of Electrical and Electronics Engineering