Program Name : **Electrical Engineering Program Group**

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

Semester : **Third**

Course Title : **Electrical and Electronic Measurements**

Course Code : **22325**

1. RATIONALE

The electrical diploma holder has to work in industry as technical person in middle level management. He has to work as production, maintenance, testing engineer in various industries like power generation, transmission, distribution, traction etc. and has to deal with different electrical measurement. While performing above task he has to measure different electrical and electronic parameters with testing, therefore he/she must require the skills for these measurements and broad idea of different meters and equipments.

2. COMPETENCY

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

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

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. Identify electrical measuring instrument.
b. Use voltmeter and ammeter for electrical measurement.
c. Use wattmeter for electrical power measurement.
d. Use energy meter for electrical energy measurement.
e. Use measuring instruments.

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
4	-	2	6	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.

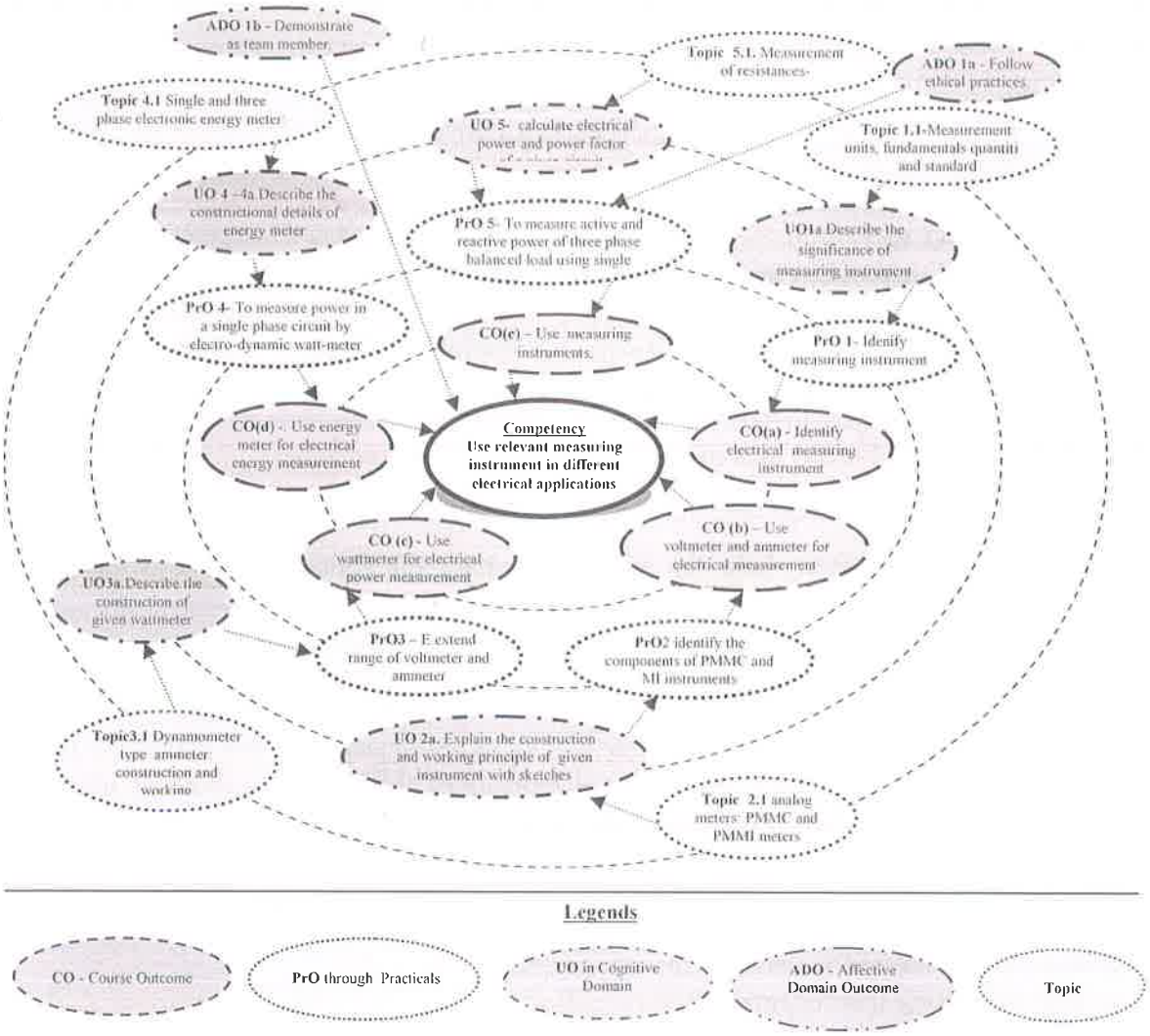

Figure 1 - Course Map

6. SUGGESTED EXERCISES/PRACTICALS

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	Identify measuring instruments on the basis of symbols on dial, type, accuracy, class position and scale.	I	2*
2	Identify the components of PMMC and MI instruments.	II	2*
3	Troubleshoot PMMC and MI instruments.	II	2*
4	Measure AC and DC quantities in a working circuit.	II	2
5	Extend range of voltmeter and ammeter by using shunt and	II	2

S.No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	multiplier, CT and PT.		
6	Use Clamp-on meter for measurement of AC/DC current, AC/DC voltage.	II	2
7	Use electro-dynamic watt-meter for measurement of power in a single phase circuit	III	2*
8	Troubleshoot electro-dynamic watt-meter for measurement of power in a single phase circuit	III	2*
9	Use single wattmeter for measurement of active and reactive power of three phase balanced load	III	2
10	Use two watt-meters for measuring active power of three-phase balanced load.	III	2
11	Calibrate single phase energy meter by direct loading.	IV	2*
12	Troubleshoot single phase energy meter.	IV	2*
13	Use digital multi-meter for measurement of AC/DC current, AC/DC voltage.	V	2
14	Use bridges for measurement of low resistance.	V	2*
15	Use bridges for measurement of medium and high resistance.	V	2
16	Use Megger for insulation measurements.	V	2
17	Use earth tester for measurement of earth resistance.	V	2
18	Use CRO for the Measurement of supply frequency in single-phase circuit using	V	2
19	Use Tri-vector meter for measuring kW, kVAr and kVA of a power line.	V	2
	Total		**38**

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 set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations 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

S. No.	Equipment Name with Broad Specifications	PrO No.
1.	Model of PMMC and MI type instrument .(upto 50A)	2
2.	Voltmeter Range (0-110V), Ammeter (0 to 5A) .	3
3.	Voltmeter Range (0-110V), Ammeter (0 to 5A), CT (15/5, 25/5), PT (230/110, 440/110).	4
4.	Voltmeter Range (0-110/230V), Ammeter (0 to 5A), Wattmeter (5/10A, 110/ 230V).	5
5.	Voltmeter Range (0-300/600V), Ammeter (0 to 5/10A), Wattmeter (5/10A, 300/ 600V).	6
6.	Voltmeter Range (0-300/600V), Ammeter (0 to5/10A), Wattmeter (5/10A, 300/ 600V) -2nos.	7
7.	Voltmeter Range (0-150/300V), Ammeter (0to5/10A), Wattmeter (5/10A, 150/ 300V), Energy meter (analog/digital) (15A/230V)	8
8.	Digital Multimeter, Rheostat (5A,100ohm), Auto transformer (0 to 300V).	9
9.	Wheatstone bridge, Mega ohm bridge	11
10.	Megger(Insulation testing upto 1000v and 100Gohm)	12
11.	Clamp on meter (Range 40A,resolution10mA,10Hz to100Hz)	13
12.	CRO (upto 100 Mhz)	15
13.	Signal Generator(upto 100Mhz)	15
14.	Funtion Generator(upto 100Mhz)	15
15.	Tri-vector(upto 100A), 3 phase 3wire, 110V (Phase to Phase)	16

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 Fundamentals of	1a. Describe the significance of the given measuring instrument. 1b. Classify the given measuring	1.1 Measurement: Significance, units, fundamental quantities and standards 1.2 Instrume...

measurements	instruments. 1c. Determine static and dynamic characteristics of the measuring instruments with the given data. 1d. Explain the procedure for calibration of given device.	a. absolute and secondary instruments b. analog and digital instruments c. mechanical, electrical and electronic instruments 1.3 Static and dynamic characteristics, types of errors 1.4 Calibration: need and procedure
Unit– II Measurement of voltage and current.	2a. Explain with sketches the construction and working principle of the specified Instrument. 2b. Convert the PMMC instrument into DC ammeter for the given range. 2c. Convert the PMMC instrument into DC voltmeter for the given range. 2d. Explain with sketches the working of given type of voltmeter.	2.1 Analog meters: Permanent magnet moving coil (PMMC) and Permanent magnet moving iron (PMMI) meter, their construction, working, salient features 2.2 DC Ammeter: Basic, Multi range, Universal shunt 2.3 DC Voltmeter: Basic, Multi range, simple numerical based on R_S, concept of loading effect and sensitivity 2.4 AC voltmeter: Rectifier type (half wave and full wave) 2.5 Ohm meter: Series and shunt 2.6 Clamp-on meter.
Unit– III Measurement of Electric Power	3a. Describe with sketches the construction of the given Wattmeter. 3b. Determine multiplying factor for the given meter. 3c. Connect wattmeter for power measurement of the given circuit. 3d. Determine the electrical power and power factor of the given circuit. 3e. Describe the selection procedure of the meters for measuring the given parameter.	3.1 Dynamometer type wattmeter: Construction and working 3.2 Range: Multiplying factor and extension of range. 3.3 Errors and compensations. 3.4 Active and reactive power measurement: One, two and three wattmeter method. 3.5 Effect of Power factor on wattmeter reading in two wattmeter method. 3.6 Maximum Demand indicator, 3.7 Four quadrant meter 3.8 Phase sequence
Unit– IV Measurement of Electric energy	4a. Describe with sketches the construction of the given energy meter 4b. Describe with sketches the connection of the given single phase energy meter for electrical energy measurement. 4c. Determine the errors in the given energy meter 4d. Select energy meter for the given application with justification. 4e. Calibrate the given type of meter.	4.1 Single and three phase electronic energy meter: Constructional features and working principle. 4.2 Errors and their compensations. 4.3 Calibration of single phase electronic energy meter using direct loading.
Unit –V	5a. Choose the method for	5.1 Measurement of resistance: Low,

Measuring Instruments	measurement of resistances for given application with justification. 5b. Describe with sketches the specified blocks and working of the given type of oscilloscope. 5c. Describe with sketches the procedure to measure the given parameter using the CRO. 5e. Describe with sketches the various blocks and working of the given type of signal/ function generator.	Medium and High; Megger and earth tester; Multimeter and L-C-R meter. 5.2 Frequency meter. 5.3 Phase sequence and Phase sequence indicator 5.4 Synchroscope and Infrared meter 5.5 Single beam/single trace CRO, Digital storage Oscilloscope: Basic block diagram, working, Cathode ray tube, electrostatic deflection, vertical amplifier, time base generator, horizontal amplifier, measurement of voltage/ amplitude/ time period/ frequency/ phase angle delay line, specifications. 5.6 Signal generator: need, working and basic block diagram. 5.7 Function generator: need, working and basic block diagram, function of symmetry. 5.8 Tri-vector meter

***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	Fundamentals of measurements	08	02	04	04	10
II	Measurement of voltage and current.	10	02	04	06	12
III	Measurement of Electric Power	10	01	04	06	11
IV	Measurement of Electric Energy	14	01	04	06	11
V	Measuring Instruments	22	04	10	12	26
Total		**64**	**10**	**26**	**34**	**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 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 chart showing real-life examples indicating various types of electrical measuring equipment
b. Collect photographs of PMMC and MI instrument showing internal parts.
c. Prepare power point presentation for different types of wattmeter.
d. Collect photographs of Digital energy meter and prepare breadboard circuit models of simple Digital energy meter.
e. Collect photographs of CRO and see the practical utilization.
f. Collect photographs of Tri-vector meter and see the practical utilization in HT/LT consumers.

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. ***'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. Guide student(s) in undertaking micro-projects.
f. Use of video, animation films to explain concepts, facts and applications related to electrical measuring instruments specially digital meters.
g. In respect of item 10 above, teachers need to ensure to create opportunities and provisions for such co-curricular activities.(use remaining practical hours).
h. Massive open online course(MOOCs) may be used to each various topics and sub – topics.

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 is given here. Similar micro-projects could be added by the concerned faculty:

a) **PMMC and MI instrument:** Dismantle any PMMC and MI instrument each available in the laboratory/workshop and Identify different parts i.e.coil, spring, magnets, former etc. and again assemble the same.

b) **Wattmeter:** Dismanlte different types of wattmeters available in the laboratory identify the pressure coil and current coil and again assemble the same.
c) **Digital energy meter**: Collect data of power consumption of the equipment installed in departmental laboratories and workshops of the polytechnic using Digital energy meter.
d) **CRO and DMM:** Using CRO and DMM test all electronic and electrical circuits in laboratory.
e) **Tri-vector meter:** Use Tri-vector meter for its practical utilization in LT consumers.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	A Text Book of Electrical Technology Vol-I (Basic Electrical Engg.)	Theraja B. L., Theraja A. K.	S.Chand and Co. New Delhi, 2014, ISBN: 9788121924405
2	Basic Electrical Engg.	Mittle V. N.	Tata McGraw-Hill New Delhi, 2005, ISBN : 978-0-07-0088572-5,
3	Electrical Technology	Edward Hughes	Pearson Education, New Delhi, 2003, ISBN-13: 978-0582405196
4	Electrical and Electronic Measurement and Instrumentation	Rajput R.K.	S.Chand and Co. New Delhi, 2008, ISBN : 9789385676017
5	Electrical and Electronics Measurements and Instrumentation.	Sawhney A.K.	Dhanpai Rai and Sons,New Delhi, 2014; ISBN : 9780000279744
6	Electrical Measurements and Measuring Instruments	Suryanarayna N.V.	S.Chand and Co. New Delhi , 2001 ISBN :8121920116

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.youtube.com
b. www.nptel.ac.in
c. www.wikipedia.com
d. www.electricaltechnology.org
e. www.howstuffworks.com
f. www.electrical4u.com