## Maharashtra State Board of Technical Education, Mumbai

## Teaching And Examination Scheme For Post S.S.C. Diploma Courses

**Program Name : Diploma in Electrical Engineering**

**Program Code : EE/EP/EU** — **With Effect From Academic Year: 2017 - 18**

**Duration of Program : 6 Semesters** — **Duration : 16 Weeks**

**Semester : Third** — **Scheme : I**

| S. N. | Course Title | Course Abbreviation | Course Code | Teaching Scheme | | | Credit (L+T+P) | Examination Scheme | | | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Theory | | | | | | Practical | | | | | | |
| | | | | | | | | Exam Duration in Hrs. | ESE | | PA | | Total | | ESE | | PA | | Total | |
| | | | | L | T | P | | | Max Marks | Min Marks | Max Marks | Min Marks | Max Marks | Min Marks | Max Marks | Min Marks | Max Marks | Min Marks | Max Marks | Min Marks | |
| 1 | Electrical Circuits | ECI | 22324 | 4 | 2 | 2 | 8 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25# | 10 | 25 | 10 | 50 | 20 | 150 |
| 2 | Electrical and Electronic Measurements | EEM | 22325 | 4 | - | 2 | 6 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25@ | 10 | 25 | 10 | 50 | 20 | 150 |
| 3 | Fundamentals of Power Electronic | FPE | 22326 | 4 | - | 2 | 6 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25# | 10 | 25 | 10 | 50 | 20 | 150 |
| 4 | Electrical Power Generation | EPG | 22327 | 4 | - | 2 | 6 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25@ | 10 | 25 | 10 | 50 | 20 | 150 |
| 5 | Electrical Materials and Wiring Practice | EMW | 22328 | 3 | - | 4 | 7 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 50@ | 20 | 50 | 20 | 100 | 40 | 200 |
| | | | **Total** | **19** | **2** | **12** | **33** | -- | **350** | -- | **150** | -- | **500** | -- | **150** | -- | **150** | -- | **300** | -- | **800** |

Student Contact Hours Per Week: **33 Hrs.** Medium of Instruction: **English**

**Theory and practical periods of 60 minutes each.** Total Marks **: 800**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination , ^ Computer Based Assessment

* 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 LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**

**Program Name** : **Electrical Engineering Program Group**

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

**Semester** : **Third**

**Course Title** : **Electrical Circuits**

**Course Code** : **22324**

## 1. RATIONALE

To maintain electrical equipments, knowledge of electrical circuits is very important. Understanding electrical circuits lays the foundation to maintain electrical and electronic devices, machines and equipment. This course will help the students to use the principles of circuit and analyze the same to diagnose and rectify the electrical circuits related problems in the industries and power utilities.

## 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 electrical systems applying AC and DC circuit fundamentals.**

## 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. Troubleshoot problems related to single phase A.C series circuits.
b. Troubleshoot problems related to single phase A.C parallel circuits.
c. Troubleshoot problems related to three phase circuit.
d. Use principles of circuit analysis to troubleshoot problems related to electric circuits.
e. Apply network theorems to troubleshoot problems related to electric circuits.

## 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 | 2 | 8 | 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.

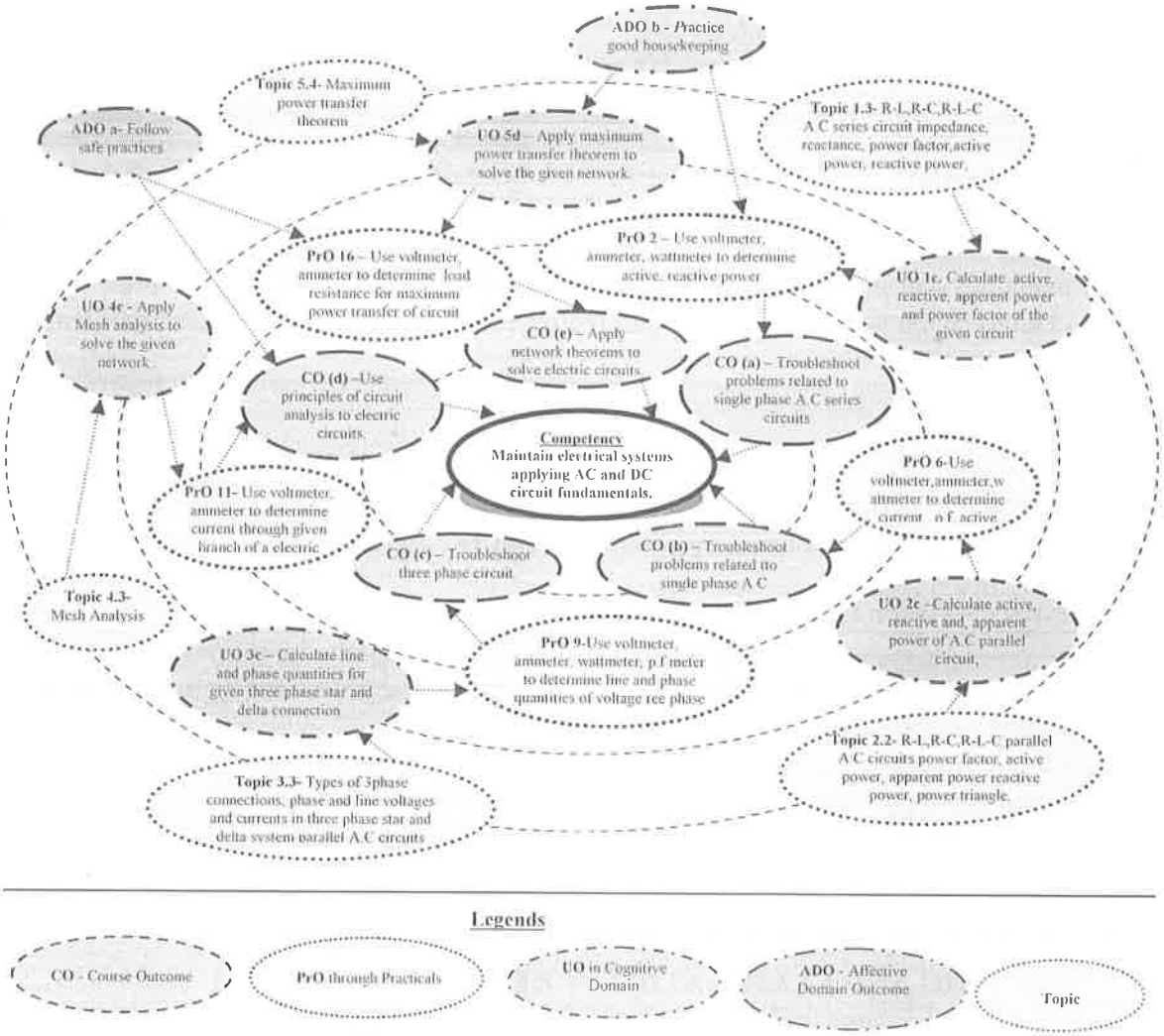


**Figure 1 - Course Map**

## 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 dual trace oscilloscope to determine A.C voltage and current response in given R,L,C circuit. | I | 02* |
| 2 | Use voltmeter, ammeter, wattmeter to determine active, reactive and apparent power consumed in given R-L series circuit. Draw phasor diagram. | I | 02 |
| 3 | Use voltmeter, ammeter to determine active, reactive and apparent power consumed in given R-C series circuit. Draw phasor diagram. | I | 02 |
| 4 | Use voltmeter, ammeter, wattmeter to determine active, reactive | I | 02 |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| | and apparent power consumed in given R-L-C series circuit. Draw phasor digram. | | |
| 5 | Use variable frequency supply to create resonance in given series R-L-C circuit or by using variable inductor or variable capacitor. | I | 02 |
| 6 | Use voltmeter, ammeter, wattmeter to determine current, p.f, active, reactive and apparent power in R-C parallel A.C. circuit. | II | 02 |
| 7 | Use voltmeter, ammeter, wattmeter, p.f meter to determine current, p.f., active. reactive and apparent power for given R-L-C parallel circuit with series connection of resistor and inductor in parallel with capacitor. | II | 02* |
| 8 | Use variable frequency supply create resonance in given parallel R-L-C circuit or by using variable inductor or capacitor . | II | 02 |
| 9 | Use voltmeter, ammeter, wattmeter, p.f meter to determine line and phase quantities of voltage and current for balanced three phase star and delta connected load and calculate active, reactive, and apparent power. Draw phasor diagram. | III | 02 |
| 10 | Use voltmeter, ammeter, wattmeter, p.f meter to determine line and phase quantities of voltage and current for unbalanced three phase star and delta connected load and calculate active, reactive, and apparent power. Draw phasor diagram. | III | 02* |
| 11 | Use voltmeter, ammeter to determine current through the given branch of a electric network by applying mesh analysis. | IV | 02* |
| 12 | Use voltmeter, ammeter to determine current through the given branch of a electric network by applying node analysis. | IV | 02 |
| 13 | Use voltmeter, ammeter to determine current through the given branch and voltage across the given element of circuit by applying superposition theorem . | V | 02 |
| 14 | Use voltmeter, ammeter to determine equivalent circuit parameter in a given circuit by applying Thevenin's theorem | V | 02* |
| 15 | Use voltmeter, ammeter to determine equivalent circuit parameter in a given circuit by applying Norton's theorem | V | 02 |
| 16 | Use voltmeter, ammeter to determine load resistance for maximum power transfer for a given circuit by applying maximum power transfer theorem . | 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 set up | 20 |

| S.No. | Performance Indicators | Weightage in % |
|---|---|---|
| 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. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. 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
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

## 7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 1 | Digital storage oscilloscope: Dual trace 50Mhz | 1 |
| 2 | Ammeters MI Type: AC/DC, 0-5-10Amp,0-1.5 Amp,0-2.5Amp,0-0.5-1Amp | 2 to 12 |
| 3 | Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V,0-75/150V | 2 to 12 |
| 4 | Wattmeter: Single phase 2.5/5Amp, 200/400V, Single phase 5/10Amp, 250/500V | 2 to 12 |
| 5 | Low power factor wattmeter : Single phase, 5/10Amp, 250/500V | 2 to 12 |
| 6 | Wattmeter : Dynamometer type, single phase, 0-750 watts,10Amp, 300-600V | 9 to 10 |
| 7 | Wattmeter: Dynamometer type, single phase, 5Amp, 250V | 2 to 12 |
| 8 | Dimmer: 1-phase,1kva,230V | 2 to 12 |
| 9 | Dimmer: 3-phase, 5kva | 9 to 10 |
| 10 | Three phase Power factor meters: AC, 415V, 50 Hz , 5-10 Amp | 9 to 10 |
| 11 | Load bank: Resistive, 3-phase, 5Kw, 415V | 9 to 10 |
| 12 | Trainer kit for all theorems | 13to 16 |
| 13 | Ammeters PMMC Type: DC, 0-1.5/3Amp, 0-2.5/5 Amp, 0-5/10Amp | 13to 16 |
| 14 | Voltmeter PMMC Type: DC, 0-150/300V, 0-250/500V,0-75/150V | 13to 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 Single Phase A.C series circuits** | 1a. Calculate impedance of the given A.C series circuit.<br>1b. Determine the current, voltage in the given A.C series circuit.<br>1c. Find active power, reactive power, apparent power and power factor of the given A.C series circuit to draw the vector diagram.<br>1d. Find voltage magnification and Q-factor of the given A.C series circuit for resonance condition.<br>1e. Describe the procedure to determine active, reactive and apparent power consumed in the given A.C series circuit using, voltmeter, ammeter, wattmeter. | 1.1 Generation of alternating voltage, Phasor representation of sinusoidal quantities<br>1.2 R,L,C circuit elements its voltage and current response<br>1.3 R-L, R-C, R-L-C combination of A.C series circuit, impedance, reactance, impedance triangle, Power factor, active power, reactive power, apparent power, power triangle and vector diagram<br>1.4 Resonance, Bandwidth, Quality factor and voltage magnification in series R-L, R-C, R-L-C circuit |
| **Unit– II Single Phase A.C parallel circuits** | 2a. Find the Impedance for the given A.C parallel circuits<br>2b. Determine the current, voltage, for the given A.C parallel circuit.<br>2c. Find the active power, reactive power, apparent power and power factor of the given A.C parallel circuit, with vector diagram.<br>2d. Apply the principles of resonance to the given A.C parallel circuit and calculate current magnification and Q-factor of the given A.C series circuit.<br>2e. Describe the procedure to determine active, reactive and apparent power consumed in the given A.C parallel circuit using, voltmeter, ammeter, wattmeter. | 2.1 R-L, R-C and R-L-C parallel combination of A.C. circuits. Impedance, reactance, phasor diagram, impedance triangle<br>2.2 R-L,R-C,R-L-C parallel A.C. circuits power factor, active power, apparent power , reactive power, power triangle<br>2.3 Resonance in parallel R-L,R-C, R-L-C circuit, Bandwidth, Quality factor and voltage magnification |
| **Unit-III Three phase circuits** | 3a. Explain the given three phase circuit diagram with justification.<br>3b. Comment regarding the balance of the given circuit with justification.<br>3c. Calculate line and phase quantities for given three phase star and delta connection.<br>3d. Determine the three phase power for the given star and delta connection. | 3.1 Phasor and complex representation of three phase supply<br>3.2 Phase sequence and polarity<br>3.3 Types of three-phase connections, Phase and line quantities in three phase star and delta system<br>3.4 Balanced and unbalanced |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | 3e. Describe the procedure to determine active, reactive and apparent power consumed in the given three phase circuit using, voltmeter, ammeter, wattmeter. | load, neutral shift in unbalanced load<br>3.5 Three phase power, active, reactive and apparent power in star and delta system |
| **Unit –IV Network Reduction and principles of DC circuit analysis** | 4a. Apply source transformation techniques for the given network.<br>4b. Reduce the given network by applying Star/delta and delta/star delta transformation.<br>4c. Apply Mesh analysis to solve the given network.<br>4d. Apply Node analysis to solve the given network.<br>4e. Describe the procedure to determine the current and voltage in the given branch of the given network applying Mesh and Node analysis. | 4.1 Source transformation<br>4.2 Star/delta and delta/star transformation<br>4.3 Mesh Analysis<br>4.4 Node Analysis |
| **Unit-V Network Theorems** | 5a. Apply superposition theorem to solve the given circuit.<br>5b. Apply Thevenin's theorem to solve the given circuit.<br>5c. Apply Norton's theorem to solve the given circuit.<br>5d. Apply maximum power transfer theorem to solve the given network.<br>5e. Describe the procedure to solve the given electric circuit by applying network theorems. | 5.1 Superposition theorem .<br>5.2 Thevenin's theorem.<br>5.3 Norton's theorem<br>5.4 Maximum power transfer theorem<br>5.5 Reciprocity theorem<br>5.6 Duality in electric circuits |

*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 | Single phase A.C series circuits | 12 | 03 | 05 | 07 | 15 |
| II | Single phase A.C parallel circuits | 12 | 03 | 04 | 06 | 13 |
| III | Three phase circuits | 10 | 03 | 04 | 06 | 13 |
| IV | Network Reduction and Principles of circuit analysis | 14 | 03 | 04 | 06 | 13 |
| V | Network Theorems | 16 | 04 | 04 | 08 | 16 |
| **Total** | | **64** | **16** | **21** | **33** | **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. Visit any 33/11kv substation nearby to your house and take the help of sub-station in-charge to know the three phase circuits and occurrences of fault.
b. Write report on accidental power off/shut down problem in hostel/ room/building.
c. Read the safety precautions of various electric equipment in residence and transformer repair shop.
d. Do internet survey and use various meters to test electrical equipment and machines in market.
e. Guide student(s) in undertaking micro-projects.
f. Library / Internet survey of electrical circuits and network
g. Prepare power point presentation or animation for understanding different circuits behavior.
h. Analyse circuit response to diagnose faults in the electric/electronic circuits.
i. Practice Pspice/matlab to analyse circuit response.

## 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. Correlate subtopics with power system utility and electrical equipements.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various theorems in circuit analysis.
i. Use Pspice/Matlab models to explain different concepts of electric circuit.

## 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. **Single Phase A.C. series and parallel Circuits:** Prepare series and parallel LED lamp/load(R,L,C) circuit. Measure the response and draw vector diagram. Calculate power factor for the circuit.
b. **Three phase balanced circuits:** Prepare three phase network of balanced load at 230volts and determine phase and line quantities and also calculate active and reactive power for the given load.
   i. Star connection
   ii. Delta connection
c. **Three phase unbalanced circuits:** Prepare three phase network of unbalanced load and determine phase and line quantities and also calculate active and reactive power for the given load.
   i. Star connection
   ii. Delta connection
d. **Principles of circuit analysis and Network theorem:** Prepare power point presentation on source transformation, star delta transformation, mesh and nodal analysis, Network theorems for the given network.
e. Solve the given Electric circuit problems using PSpice/Matlab software.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Fundamentals of Electrical Networks | Gupta, B.R ; Singhal, Vandana | S.Chand and Co., New Delhi, 2005 ISBN : 978-81-219-2318-7 |
| 2 | Fundamentals of Electrical Engineering | Saxena, S.B lal ; Dasgupta, K. | Cambridge university press pvt. Ltd., New Delhi, 2016, ISBN : 978-11-0746-435-3 |
| 3 | A Text Book of Electrical Technology Vol-I | Theraja, B. L. ; Theraja, A. K. | S. Chand & Co. Ramnagar, New Delhi, 2012; ISBN : 9788121924405 |
| 4 | Circuit and network | Sudhakar, A. ; Shyammohan, S.palli | McGraw Hill Education, New Delhi, 2015, ISBN : 978-93-3921-960-4 |
| 5 | Electric Circuits | Bell, David A. | Oxford University Press New Delhi, 2009; ISBN : 978-01-954-2524-6 |
| 6 | Schaum online series-Theory & problems of electric circuits | Edminister. | McGraw Hill Education, Newyork, 2013, ISBN: 978-00-701-8999 |
| 7 | Introductory circuit | Boylested, R.L. | Wheeler, New Delhi , 2013 |

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| | Analysis. | | ISBN: 978-00-231-3161-5 |
| 8 | Basic Electrical Engineering | Mittle, V.N. ; Mittle, Arvind | McGraw Hill Education, Noida, 2005 ISBN: 978-00-705-9357-2 |
| 9 | Electric Circuit Analysis | Sivanandam, S.N. | Vikas publishing house pvt. Ltd, Noida, 2002; ISBN:978-81259-1364-1 |
| 10 | Circuit theory | Salivahanan, S.; Pravin kumar, S. | Vikas publishing house pvt. Ltd, Noida, 2014; ISBN:978-93259-7418-0 |

## 14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.cesim.com/simulations
b. www.scilab.org/scilab
c. www.ni.com/multisim
d. www.youtube.com /electric circuits
e. www.dreamtechpress.com /ebooks
f. www.nptelvideos.in/electrical engineering/ circuit theory
g. www.learnerstv.com/free-engineering
h. www.orcad.com/resources/orcad-downloads

**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.

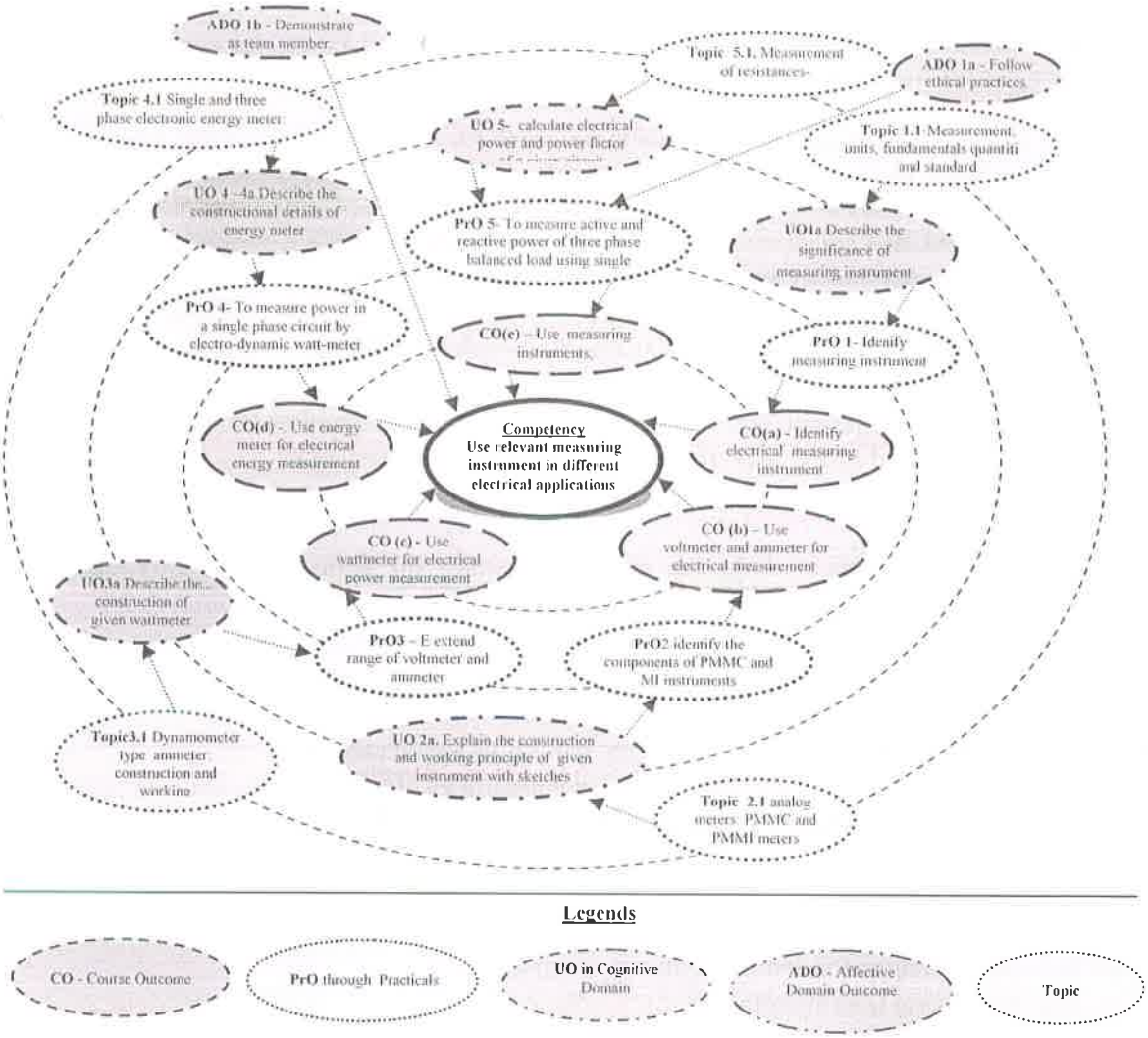


**Figure 1 - Course Map**

## 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.<br>1b. Classify the given measuring | 1.1 Measurement: Significance, units, fundamental quantities and standards<br>1.2 Instrum... |

| | | |
|---|---|---|
| **measurements** | instruments.<br>1c. Determine static and dynamic characteristics of the measuring instruments with the given data.<br>1d. Explain the procedure for calibration of given device. | a. absolute and secondary instruments<br>b. analog and digital instruments<br>c. mechanical, electrical and electronic instruments<br>1.3 Static and dynamic characteristics, types of errors<br>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.<br>2b. Convert the PMMC instrument into DC ammeter for the given range.<br>2c. Convert the PMMC instrument into DC voltmeter for the given range.<br>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<br>2.2 DC Ammeter: Basic, Multi range, Universal shunt<br>2.3 DC Voltmeter: Basic, Multi range, simple numerical based on $R_S$, concept of loading effect and sensitivity<br>2.4 AC voltmeter: Rectifier type (half wave and full wave)<br>2.5 Ohm meter: Series and shunt<br>2.6 Clamp-on meter. |
| **Unit– III Measurement of Electric Power** | 3a. Describe with sketches the construction of the given Wattmeter.<br>3b. Determine multiplying factor for the given meter.<br>3c. Connect wattmeter for power measurement of the given circuit.<br>3d. Determine the electrical power and power factor of the given circuit.<br>3e. Describe the selection procedure of the meters for measuring the given parameter. | 3.1 Dynamometer type wattmeter: Construction and working<br>3.2 Range: Multiplying factor and extension of range.<br>3.3 Errors and compensations.<br>3.4 Active and reactive power measurement: One, two and three wattmeter method.<br>3.5 Effect of Power factor on wattmeter reading in two wattmeter method.<br>3.6 Maximum Demand indicator,<br>3.7 Four quadrant meter<br>3.8 Phase sequence |
| **Unit– IV Measurement of Electric energy** | 4a. Describe with sketches the construction of the given energy meter<br>4b. Describe with sketches the connection of the given single phase energy meter for electrical energy measurement.<br>4c. Determine the errors in the given energy meter<br>4d. Select energy meter for the given application with justification.<br>4e. Calibrate the given type of meter. | 4.1 Single and three phase electronic energy meter: Constructional features and working principle.<br>4.2 Errors and their compensations.<br>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.<br>5b. Describe with sketches the specified blocks and working of the given type of oscilloscope.<br>5c. Describe with sketches the procedure to measure the given parameter using the CRO.<br>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.<br>5.2 Frequency meter.<br>5.3 Phase sequence and Phase sequence indicator<br>5.4 Synchroscope and Infrared meter<br>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.<br>5.6 Signal generator: need, working and basic block diagram.<br>5.7 Function generator: need, working and basic block diagram, function of symmetry.<br>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

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

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

**Semester** : **Third**

**Course Title** : **Fundamentals of Power Electronics**

**Course Code** : **22326**

## 1. RATIONALE

Day by day the enhanced development in the industry is dynamic. The role of technicians (Diploma engineers) has changed over the years. Power electronic devices and circuits play a major role in nearly all industries. By virtue of their operating characteristics; for which study of these devices is very essential for the electrical and electronic technician to handle them. Hence they must be well conversant with the power electronic devices and their applications. This course aims to impart the knowledge and skills related to handling in terms of the applications and maintenance of these devices.

## 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 the proper functioning of power electronic devices.**

## 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 power electronic devices for specific applications.
b. Maintain the performance of Thyristors.
c. Troubleshoot turn-on and turn-off circuits of Thyristors.
d. Maintain phase controlled rectifiers.
e. Maintain industrial control circuits.

## 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.

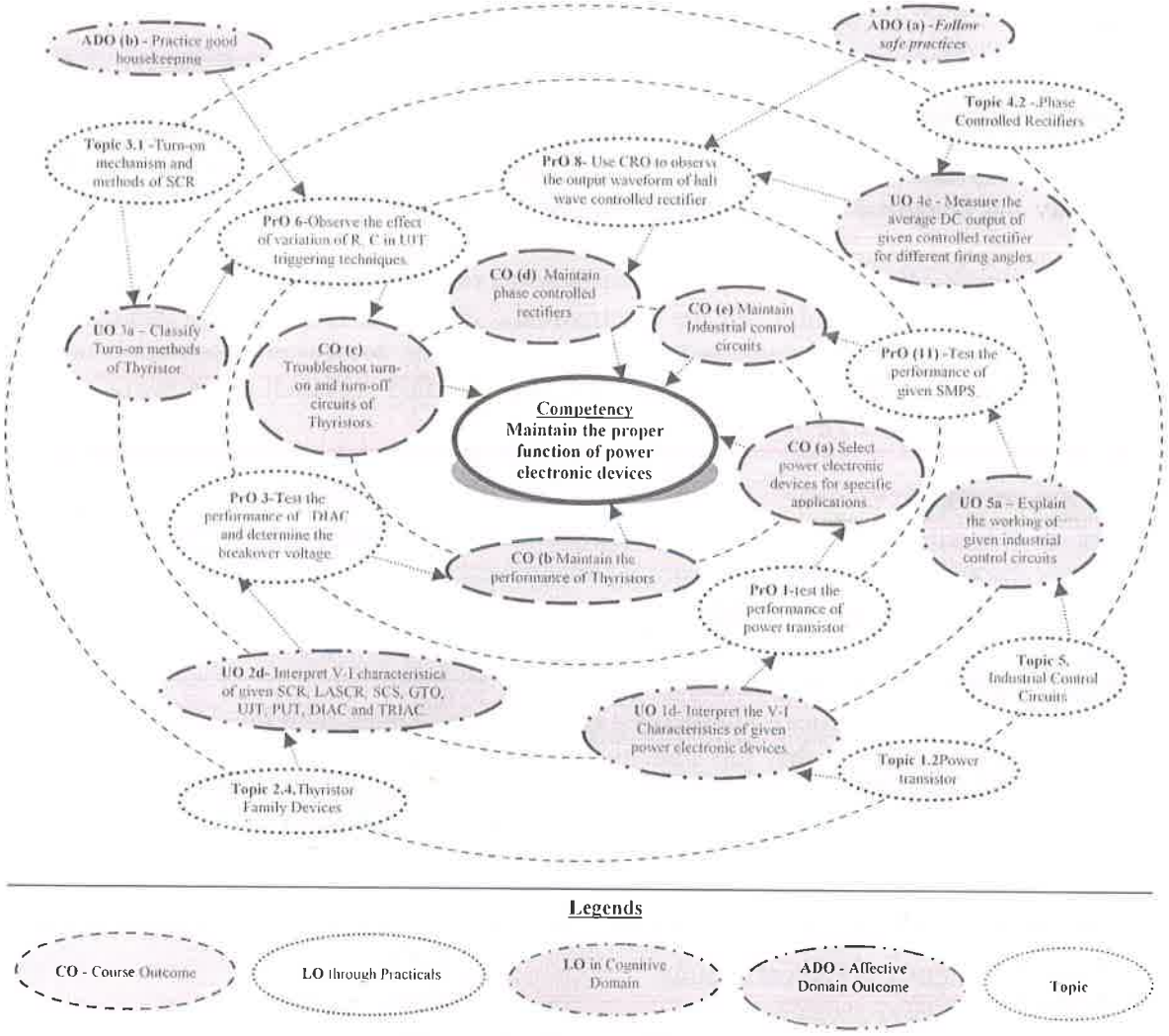


**Figure 1 - Course Map**

## 6. SUGGESTED 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 | Test the proper functioning of power transistor. | I | 02* |
| 2 | Test the proper functioning of IGBT. | I | 02 |
| 3 | Test the proper functioning of DIAC to determine the break over voltage. | II | 02* |
| 4 | Determine the latching current and holding current using V-I characteristics of SCR. | II | 02 |
| 5 | Test the variation of R,C in R and RC triggering circuits on firing angle of SCR. | III | 02* |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 6 | Test the effect of variation of R, C in UJT triggering technique. | III | 02 |
| 7 | Perform the operation of Class – A, B, C, turn off circuits. | III | 02 |
| 8 | Perform the operation of Class –D, E, F turn off circuits. | III | 02 |
| 9 | Use CRO to observe the output waveform of half wave controlled rectifier with resistive load and determine the load voltage. | IV | 02* |
| 10 | Draw the output waveform of Full wave controlled rectifier with R load, RL load, freewheeling diode and determine the load voltage. | IV | 02 |
| 11 | Determine the firing angle using DIAC and TRIAC phase controlled circuit on output power under different loads such as lamp , motor or heater | V | 02* |
| 12 | Simulate above firing angle control on SCILAB software | V | 02* |
| 13 | Test the performance of given SMPS. | V | 02 |
| 14 | Test the performance of given UPS | V | 02 |
| 15 | Troubleshoot the Burglar's alarm. | V | 02 |
| 16 | Troubleshoot the Emergency light system. | V | 02 |
| 17 | Troubleshoot the Speed control system. | V | 02 |
| 18 | Troubleshoot the Temperature control system. | V | 02 |
| | **Total** | | **36** |

***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. | Correctness of circuit diagrams | 40 |
| b. | Troubleshooting ability | 20 |
| c. | Quality of input and output displayed ( observing , measuring, plotting and analysis of graph/characteristics/parameters) | 10 |
| d. | Answer to sample questions | 20 |
| e. | Submit 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
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

## 7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher 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 | Digital Multimeter: 3and1/2 digit 0-800Volts,0-10A , Micro-ammeters:0-100uA | All |
| 2 | Dual channel CRO: 25 MHz with isolation transformer OR Power scope , Attenuator probe for CRO | All |
| 3 | SCR, LASCR, SCS, GTO, UJT, PUT, DIAC and TRIAC – 5 each | All |
| 4 | DC Regulated Power Supply: 0-300 V,0- 10 A | 1 to 7 |
| 5 | Experimental kits related to Thyristors, connecting cords | All |
| 6 | Resistive load: (Lamp100W, heater coil 500W), Resistive-Inductive load: (single phase fractional ¼ HP, 60W,75W Motor) | 8,9,10 |
| 7 | Digital Tachometer with opto-coupler (phototechometer ) 4000 RPM | 15 |
| 8 | SCILAB Software | 10 |

## 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 Power Electronic Devices** | 1a. Explain with sketches the working of the given power electronic device(s).<br>1b. Describe with sketches the construction of the given power transistor.<br>1c. Interpret the V-I characteristics of the given power electronic device.<br>1d. Select suitable power electronic device for given situation with justification.<br>1e. Suggest suitable IGBT for given application.<br>1f. Describe the procedure to troubleshoot the given power | 1.1 Power electronic devices<br>1.2 Power transistor: construction, working principle, V-I characteristics and uses.<br>1.3 IGBT: Construction, working principle, V-I characteristics and uses.<br>1.4 Concept of single electron transistor (SET) - aspects of Nano-technology. |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | electronic device (s) | |
| **Unit– II Thyristor Family Devices** | 2a. Classify given power semiconductor devices<br>2b. Identify given thyristors and triggering devices with justification<br>2c. Explain with sketches the working of the given type of thyristor<br>2d. Describe the procedure to troubleshoot the given type of thyristor. | 2.1 SCR: construction, two transistor analogy, types, working and V-I characteristics.<br>2.2 SCR mounting and cooling.<br>2.3 Types of Thyristors: SCR, LASCR, SCS, GTO, UJT, PUT, DIAC and TRIAC<br>2.4 Thyristor family devices: symbol, construction, operating principle and V-I characteristics.<br>2.5 Protection circuits: over-voltage, over-current, Snubber, Crowbar. |
| **Unit– III Turn-on and Turn-off Methods of Thyristors** | 3a. Explain with sketches the working of the given type of triggering circuit.<br>3b. Explain the role of pulse transformer in given triggering circuits.<br>3c. Explain with sketches the working of the given type of turn-on method.<br>3d. Describe the procedure to troubleshoot the given type of turn-on method.<br>3e. Explain with sketches the working of the given type of turn-off method.<br>3f. Describe the procedure to troubleshoot the given type of turn-off method. | 3.1 SCR Turn-ON methods: High Voltage thermal triggering, Illumination triggering, dv/dt triggering, Gate triggering.<br>3.2 Gate trigger circuits – Resistance and Resistance-Capacitance circuits.<br>3.3 SCR triggering using UJT, PUT: Relaxation Oscillator and Synchronized UJT circuit.<br>3.4 Pulse transformer and opto-coupler based triggering.<br>3.5 SCR Turn-OFF methods: Class A- Series resonant commutation circuit, Class B-Shunt resonant commutation circuit, Class C-Complimentary Symmetry commutation circuit, Class D –Auxiliary commutation, Class E- External pulse commutation , Class F- Line or natural commutation. |
| **Unit-IV Phase Controlled Rectifiers** | 4a. Explain with sketches the operation of the phase control.<br>4b. Calculate the average voltage of the given controlled rectifier.<br>4c. Interpret / draw the input-output waveforms of the power electronic circuit.<br>4d. Explain with sketches the operation of the given bridge configuration.<br>4e. Describe the procedure to troubleshoot the given phase controlled rectifier(s) circuit. | 4.1 Phase control: firing angle, conduction angle.<br>4.2 Single phase half controlled, full controlled and midpoint controlled rectifier with R, RL load: Circuit diagram, working, input- output waveforms, equations for DC output and effect of freewheeling diode.<br>4.3 Different configurations of bridge controlled rectifiers: Full bridge, half bridge with common anode, common cathode, SCRs in one arm and diodes in another arm. |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| **Unit –V Industrial Control Circuits** | 5a. Explain with sketches the working of given industrial control circuits.<br>5b. Describe the troubleshooting procedure of the given type of SMPS.<br>5c. Describe the troubleshooting procedure of the given type of online and offline UPS.<br>5d. Explain with sketches the working of the given type of SCR-based circuit breaker.<br>5e. Describe the procedure to troubleshoot phase controlled rectifier(s). | 5.1 Applications: Burglar's alarm system, Battery charger using SCR, Emergency light system, Temperature controller using SCR and; Illumination control / fan speed control using TRIAC.<br>5.2 SMPS.<br>5.3 UPS: Offline and Online<br>5.4 SCR based AC and DC circuit breakers. |

***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 FORQUESTION PAPER DESIGN

| Unit No. | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A Level | Total Marks |
| I | Power Electronic Devices | 08 | 01 | 02 | 03 | 06 |
| II | Thyristor Family Devices | 16 | 03 | 06 | 08 | 17 |
| III | Turn-on and Turn-off Methods of Thyristors | 14 | 03 | 04 | 07 | 14 |
| IV | Phase Controlled Rectifiers | 18 | 02 | 06 | 10 | 18 |
| V | Industrial Control Circuits. | 08 | 02 | 05 | 08 | 15 |
| **Total** | | **64** | **11** | **23** | **36** | **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. Visit the nearby power electronics based industry and observe the processes.
b. Take the market survey of various specifications of available Thyristors and submit the report of their uses.
c. Survey the market and submit the report of available circuit breakers, SMPS and different types of UPSs.

d. Survey the local market and identify the different types of fan regulator available in the market.

## 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).
a. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
b. Guide student(s) in undertaking micro-projects
c. Use simulation software's for demonstrating the performance of different Thyristors.

## 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. **Power Electronic Devices:** Build and test the circuit of electronic switch using power transistor and control the operation with wireless devices.
b. **Thyristor family devices:** Build and test the circuit of digital logic gates : AND , OR , NOT , NAND , NOR , Ex-OR , Ex-NOR using SCRs ( any four).
c. **Turn-on and Turn-off methods:** Build and test the circuit of
   i) PUT and
   ii) UJT relaxation oscillator.
d. **Phase controlled rectifier:** Construct and test a circuit of fractional HP DC motor speed control (Open Loop) .
e. **Industrial control circuits:** Build and test circuit of
   i) fan regulator using TRIAC – DIAC or
   ii) SCR lamp flasher.
f. Any Other Micro Project: based on the curriculum suggested by the Teacher.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | An Introduction to Thyristors and their applications | Ramamoorty M. | East-West Press Pvt. Ltd., New Delhi, 1980, ISBN: 8185336679. |
| 2 | Thyristors: Theory and Applications | Sugandhi, Rajendra Kumar and Sugandhi, Krishna Kumar. | New Age International (P) ltd. Publishers, New Delhi, 2009, ISBN: 978-0-85226-852-0. |
| 3 | Fundamentals of Power Electronics | Bhattacharya, S.K. | Vikas Publishing House Pvt. Ltd. Noida. 2009,ISBN: 978-8125918530. |
| 4 | Power Electronics and its Applications | Jain, Alok | Penram International Publishing (India) Pvt. Ltd, Mumbai, 2006 ISBN: 978-8187972228. |
| 5 | Power Electronics Circuits Devices and Applications | Rashid , Muhammad, H. | Pearson Education India, Noida, 2014 ISBN: 978-0133125900. |
| 6 | Power Electronics | Singh, M. D. and Khanchandani, K.B. | Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2008 ISBN: 9780070583894. |
| 7 | Industrial Electronics: A Text –Lab Manual | Zbar, Paul B. | McGraw Hill Publishing Co. Ltd. , New Delhi, 1990 ISBN: 978-0070728226. |
| 8 | SCR Manual | Grafham D.R. | General Electric Co., 1982 ISBN: 978-0137967711. |
| 9 | Understanding the Nanotechnology Revolution | Edward L Wolf and Manasa Mediconda | Wiley- VCH verlag GmbH and Co. kGaA, ISBN: 978-3527411092 |

## 14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.nptel.ac.in/courses/108101038
b. www.ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-334-power-electronics-spring-2007
c. SCILab
d. www.nptelvideos.in/2012/11/power-electronics.html
e. www.coursera.org/learn/power-electronics
f. www.powerguru.org/power-electronics-videos/
g. www.youtube.com/watch?v=1Auay7ja2oY

**Program Name** : **Electrical Engineering Program Group**

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

**Semester** : **Third**

**Course Title** : **Electric Power Generation**

**Course Code** : **22327**

## 1. RATIONALE

Electrical power plays significant role in the development of industries and agriculture. With growing demand of electric power and diminishing of fossil fuels it has become important to generate power more efficiently. This course therefore deals in detail about generation of electric power using Thermal (Coal), Hydro, Nuclear fuels, Diesel and gas. These types of power plants need highly skilled technicians who are capable of operating various control equipment to supply uninterrupted power. This course attempts to develop the basic cognitive skills required to take appropriate decisions to maintain the various generating and auxiliary equipment of power plants and also aid for further studies in transmission, distribution, utilization and protection of power system for smooth and steady operation.

## 2. COMPETENCY

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

- **Maintain the efficient operation of various electric power generating plants.**

## 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. Maintain the optimised working of the thermal power plant.
b. Maintain the optimised working of large and micro hydro power plants.
c. Maintain the optimised working of solar and biomass-based power plants.
d. Maintain the optimised working of wind power plants.
e. Select the adequate mix of power generation based on economic operation.

## 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*

***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.

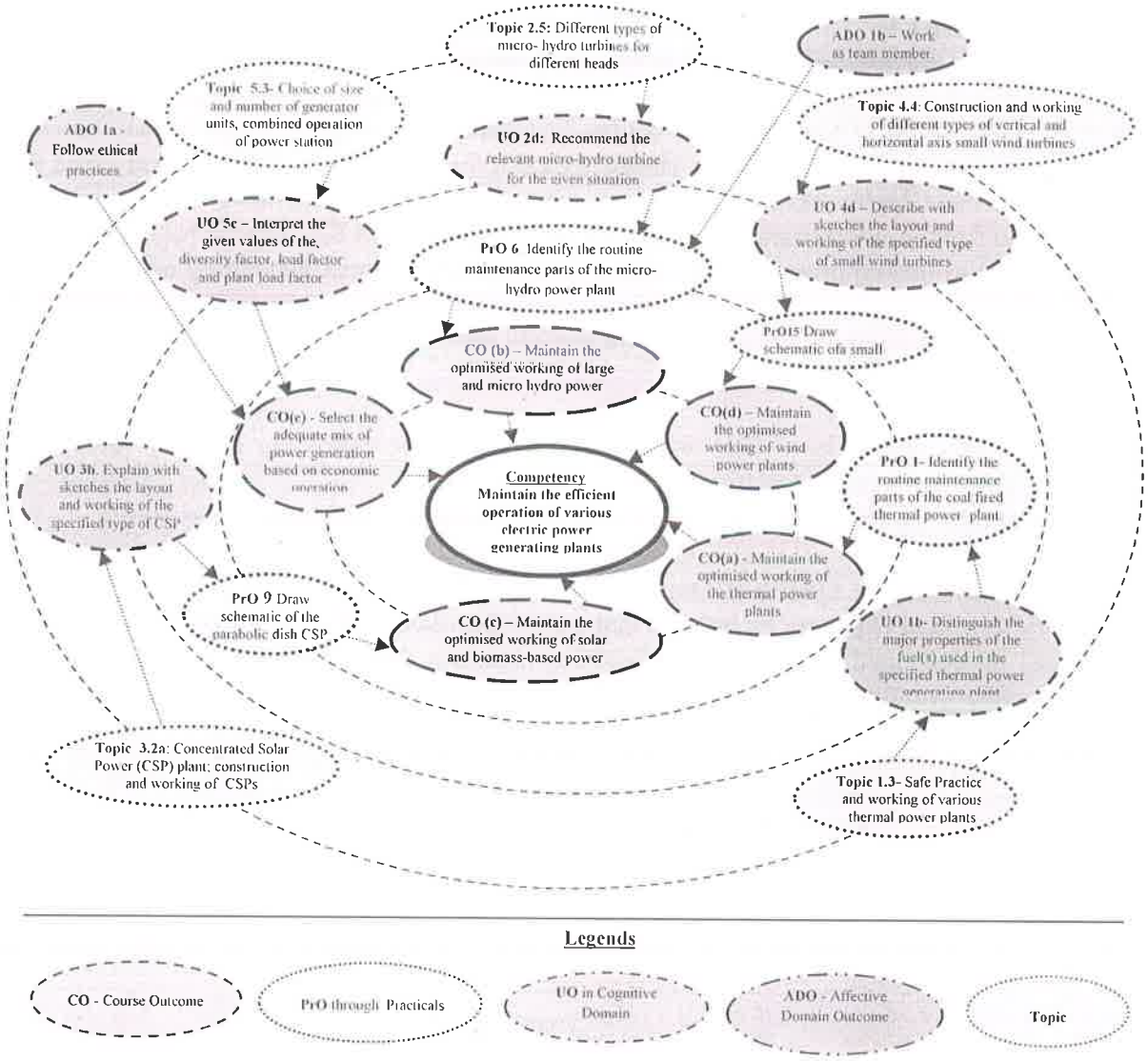


**Figure 1 Course Map**

## 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 | Identify the routine maintenance parts of the coal fired thermal power plant after watching a video programme | I | 02 |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 2 | Identify the routine maintenance parts of the gas fired thermal power plant after watching a video programme | I | 02 |
| 3 | Draw schematic of a small diesel generator power plant. | I | 02* |
| 4 | Identify the parts of the nuclear fired thermal power plant after watching a video programme. | I | 02 |
| 5 | Identify the routine maintenance parts of the large hydro power plant after watching a video programme | II | 02 |
| 6 | Identify the routine maintenance parts of the micro hydro power plant after watching a video programme. | II | 02 |
| 7 | Draw the schematic of a micro hydro power plant. | II | 02* |
| 8 | Draw the schematic of the parabolic trough Concentrated Solar Power (CSP) plant. | III | 02* |
| 9 | Draw the schematic of the parabolic dish CSP plant. | III | 02* |
| 10 | Draw the schematic of the solar PV plant. | III | 02* |
| 11 | Draw the schematic small biogas plant to generate electric power | III | 02* |
| 12 | Draw schematic of the biogas plant. | III | 02 |
| 13 | Identify the routine maintenance parts of the large wind power plant after watching a video programme. | IV | 02* |
| 14 | Draw schematic of a horizontal axis small wind turbine. | IV | 02 |
| 15 | Draw schematic of a vertical axis small wind turbine | IV | 02* |
| 16 | Identify the routine maintenance parts of the horizontal axis small wind turbine after watching a video programme. | IV | 02* |
| 17 | Identify the routine maintenance parts of the vertical axis small wind turbine after watching a video programme. | IV | 02 |
| | **Total** | | **34** |

***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 % |
|---|---|---|
| 1 | Observations and Recording of different aspects of the viewed video programme | 10 |
| 2 | Use of relevant tools when assembling power plants and accessories | 20 |
| 3 | Use of relevant tools when dismantling power plants and accessories | 20 |
| 4 | Observations and Recording | 10 |
| 5 | Interpretation of result and Conclusion | 20 |
| 6 | Answer to sample questions | 10 |
| 7 | 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. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. 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
- 'Organising Level' in 2nd year

g. 'Characterising Level' in 3rd year.

## 7. MAJOR EQUIPMENT/ INSTRUMENTS SUGGESTED BUT NOT COMPULSORILY NEEDED

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 1 | Video programme on coal fired thermal power plant – part I | 1 |
| 2 | Video programme on coal fired thermal power plant – part II | 1 |
| 3 | Video programme on gas fired thermal power plant – part I | - |
| 4 | 2 to 5 kW Diesel generator set with relevant auxiliaries | 3 |
| 5 | Video programme on nuclear powered thermal power plant – part I | 4 |
| 6 | Video programme on nuclear powered thermal power plant – part II | 4 |
| 7 | Video programme on large hydro power plant – part I | 5 |
| 8 | Video programme on large hydro power plant – part II | 5 |
| 9 | Video programme on micro hydro power plant – part I | 6 |
| 10 | Video programme on micro hydro power plant – part II | 7 |
| 11 | 1 to 3 kW microhydro power plant with relevant auxiliaries | 7 |
| 12 | 1 to 3 kW parabolic trough Concentrated Solar Power (CSP) plant with relevant auxiliaries | 8 |
| 13 | 1 to 3 kW parabolic dish Concentrated Solar Power (CSP) plant with relevant auxiliaries | 9 |
| 14 | 1 to 3 kW solar PV plant with solar tracking arrangement | 10 |
| 15 | 1 to 3 kW biogas plant with relevant auxiliaries | 11,12 |
| 16 | Video programme on large wind power plant – part I | 13 |
| 17 | Video programme on large wind power plant – part II | 13 |
| 18 | Video programme on small wind power plant – part I | 14 |
| 19 | Video programme on small wind power plant – part II | 14 |
| 20 | 1 to 5 kW horizontal axis small wind turbine with towers | 14 |
| 21 | 0.5 to1 kW vertical axis wind turbine with towers | 15 |
| 22 | Video programme on horizontal axis small wind turbine. | 16 |

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 23 | Video programme on vertical axis small wind turbine. | 17 |
| 24 | Computer simulations of all the above power plants | All |

## 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 Thermal Power Plants: Coal, Gas/ Diesel and Nuclear-based** | 1a. Describe the layout of the electric power generating process with labeled block diagram of the specified thermal power plant.<br>1b. Distinguish the major properties of the fuel(s) that is used in the specified thermal power generating plant(s).<br>1c. Explain with sketches working of the given type of nuclear power plant.<br>1d. Explain with sketches the function of the specified thermal power plant auxiliary.<br>1e. Describe the specified safe practice to the followed with respect to specified thermal power plant.<br>1f. State the location of the specified thermal power plant in Maharashtra | 1.1 Layout and working of a typical thermal power plant with steam turbines and electric generators.<br>1.2 Properties of conventional fuels used in the energy conversion equipment used in thermal power plants: Coal, Gas/ diesel, Nuclear fuels –fusion and fission action<br>1.3 Safe Practices and working of various thermal power plants: coal-based, gas-based, diesel-based, nuclear-based.<br>1.4 Functions of the following types of thermal power plants and their major auxiliaries:<br>a. Coal fired boilers: fire tube and water tube.<br>b. Gas/diesel based combustion engines<br>c. Types of nuclear reactors: Disposal of nuclear waste and nuclear shielding.<br>1.5 Thermal power plants in Maharashtra. |
| **Unit – II Large and Micro-hydro Power Plants** | 2a. Identify the type of the hydro turbine required for the given site data with justification.<br>2b. Explain with sketches the construction and working of the specified type of hydro power plant for the given head.<br>2c. Explain the layout with sketches the working of the given type of micro-hydro power plant.<br>2d. Recommend the relevant | 2.1 Energy conversion process of hydro power plant.<br>2.2 Classification of hydro power plant: High, medium and low head.<br>2.3 Construction and working of hydro turbines used in different types of hydro power plant:<br>a. High head – Pelton turbine<br>b. Medium head – Francis turbine<br>c. Low head – Kaplan turbine.<br>2.4 Safe Practices for hydro power plants.<br>2.5 Different types of micro- hydro turbines for different heads: Pelton, Francis and Kaplan turbines |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | micro-hydro turbine for the given situation with justification.<br>2e. Describe the specified safe practices to the followed with respect to hydro power plants. | 2.6 Locations of these different types of large and micro-hydro power plants in Maharashtra<br>2.7 Potential locations of micro-hydro power plants in Maharashtra. |
| **Unit– III Solar and Biomass based Power Plants** | 3a. Mark the location of the given global solar power radiation values in the map of India.<br>3b. Explain with sketches the layout and working of the specified type of CSP.<br>3c. Describe with sketches the layout and working of the specified type of solar power plant.<br>3d. Explain with sketches the layout of the specified type of biomass-based power plant.<br>3e. Describe the features and the energy extraction process of the given type of biomass fuel. | 3.1 **Solar Map of India:** Global solar power radiation.<br>3.2 **Solar Power Technology**<br>a. Concentrated Solar Power (CSP) plants, construction and working of: Power Tower, Parabolic Trough, Parabolic Dish, Fresnel Reflectors<br>b. Solar Photovoltaic (PV) power plant: layout, construction, working.<br>3.3 **Biomass-based Power Plants**<br>a. Layout of a Bio-chemical based (e.g. biogas) power plant:<br>b. Layout of a Thermo-chemical based (e.g. Municipal waste) power plant<br>c. Layout of a Agro-chemical based (e.g. bio-diesel) power plant<br>3.4 Features of the solid, liquid and gas biomasses as fuel for biomass power plant. |
| **Unit– IV Wind Power Plants** | 4a. Mark the locations of the given wind power density values in the given map of India.<br>4b. Describe with sketches the layout and working of the specified type of large wind power plant.<br>4c. Differentiate the salient features of the specified type of electric generators used in large wind power plants. | 4.1 Wind Map of India: Wind power density in watts per square meter<br>4.2 Layout of Horizontal axis large wind power plant:<br>a. Geared wind power plant.<br>b. Direct drive wind power plant.<br>4.3 Salient Features of electric generators used in large wind power plants:<br>a. Constant Speed Electric Generators: Squirrel Cage Induction Generators (SCIG), Wound Rotor Induction Generator (WRIG)<br>b. Variable Speed Electric Generators: Doubly-fed induction generator (DFIG), wound rotor synchronous generator (WRSG), permanent magnet synchronous generator (PMSG) |
| | 4d. Describe with sketches the layout and working of the specified type of | 4.4 Construction layout of different types of horizontal and vertical axis small wind turbines |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | horizontal/vertical axis small wind turbine.<br>4e. Recommend the relevant small wind turbine for the specified location. | 4.5 Working of different types of horizontal and vertical axis small wind turbines: direct-drive and geared; permanent magnet generators and induction generators.<br>4.6 Location and installation of small wind turbines |
| **Unit– V Economics of Power generation and Interconnected power system** | 5a. Interpret the given load curve, load duration curve, integration duration curve<br>5b. Interpret the given values of the demand factor, plant capacity factor, plant use factor.<br>5c. Interpret the given values of the, diversity factor, load factor and plant load factor<br>5d. State the causes and impact of the given grid system fault | 5.1 Related terms: connected load, firm power, cold reserve, hot reserve, spinning reserve. Base load and peak load plants; Load curve, load duration curve, integrated duration curve<br>5.2 Cost of generation: Average demand, maximum demand, demand factor, plant capacity factor, plant use factor, diversity factor, load factor and plant load factor.<br>5.3 Choice of size and number of generator units, combined operation of power station.<br>5.4 Causes and Impact and reasons of Grid system fault: State grid, national grid, brownout and black out; sample blackouts at national and international level |

***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 | Thermal Power Plants: Coal, Gas/ Diesel and Nuclear-based. | 20 | 03 | 04 | 06 | 13 |
| II | Large and Micro-Hydro Power Plants. | 10 | 04 | 04 | 08 | 16 |
| III | Solar and Biomass Power Plants. | 12 | 04 | 04 | 08 | 16 |
| IV | Wind Power Plants. | 12 | 02 | 03 | 05 | 10 |
| V | Economics of Power Generation and Interconnected Power System . | 10 | 03 | 04 | 08 | 15 |
| **Total** | | **64** | **16** | **19** | **35** | **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. Illustrate importance of electrical energy requirement.
b. Prepare models in the form of mini-projects.
c. Prepare power point presentation related to power plants
d. Prepare charts of power plants.
e. Collect data of conventional generation for India and Maharashtra.

## 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. At least one visit to any one generating plant.

## 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. Prepare a labeled clay model and other materials of coal fired thermal power plant.
b. Prepare a labeled clay model and other materials of gas fired thermal power plant.
c. Prepare a labeled clay model and other materials of diesel fired thermal power plant.
d. Prepare a labeled clay model and other materials of nuclear powered thermal power plant.
e. Prepare a labeled clay model and other materials of large hydro power plant.
f. Prepare a labeled clay model and other materials of micro hydro power plant.
g. Prepare a labeled clay model and other materials of CSP plant.
h. Design a small wind turbine or some of its components.

i. Prepare a clay model and other materials of electric grid system.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Power plant Engineering | Nag P K | McGraw Hill, New Delhi, 2017 ISBN: 978-9339204044 |
| 2 | A course in electrical power. | Gupta, J.B. | S. K Kataria and sons, New Delhi. 2014, ISBN: 9789350143742 |
| 3 | Wind Power Technology | Earnest, Joshua | PHI Learning, New Delhi, 2015, ISBN:978-81-203-5166-0 |
| 4 | Solar Energy | Solanki, Chetan Singh | PHI Learning, New Delhi, 2016, ISBN:978-81-203-5111-0 |
| 5 | Generation of electrical Energy | Gupta, B.R. | S.Chand & Co. New Delhi, 2010, ISBN: 9788121901024 |
| 6 | A course in electrical power. | Soni, Gupta, Bhatnagar | Dhanpatrai and sons, New Delhi, 2010, ISBN: 9789350143742 |
| 7 | Principles of power system | Mehta, V.K. and Rohit mehta | S.Chand & Co. New Delhi, 2005, ISBN: 9788121924962 |

## 14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.ntpc.co.in
b. www.nhpcindia.com
c. http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/
d. http://mnre.gov.in/file-manager/grid-wind/guideline-wind.pdf
e. http://mnre.gov.in/schemes/grid-connected/solar/
f. http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/
g. http://mnre.gov.in/schemes/grid-connected/biomass-gasification/
h. http://mnre.gov.in/schemes/grid-connected/biogas/
i. http://mnre.gov.in/schemes/new-technologies/biofuels/
j. http://mnre.gov.in/schemes/grid-connected/small-hydro/
k. http://mnre.gov.in/schemes/new-technologies/geothermal/
l. http://mnre.gov.in/schemes/new-technologies/tidal-energy/
m. http://mnre.gov.in/schemes/new-technologies/hydrogen-energy/
n. www.powergridindia.com
o. www.howstuffworks.com
p. www.electrical4u.co
q. www.meda.com

**Program Name** : **Electrical Engineering Program Group**

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

**Semester** : **Third**

**Course Title** : **Electrical Materials and Wiring Practice**

**Course Code** : **22328**

## 1. RATIONALE

Electrical diploma engineers (also called as electrical technologists) are required to work as supervisors in small and large scale industries the construction field. They should be well equipped with the skills of wiring related to the electrical engineering field. They should also be able to select relevant electrical materials and accessories for different applications while carrying out original works or maintenance works. Hence they should be well conversant with the specifications of material as per the applications. This course will arm the students to face such situations successfully with confidence.

## 2. COMPETENCY

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

- **Plan and carry out wiring/cabling activities using relevant materials following safe practices.**

## 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. Follow safe practices when undertaking electrical works.
b. Select relevant conductors and electromagnetic/magnetic materials.
c. Select relevant insulating materials.
d. Perform different types of electrical wiring/cabling activities.
e. Implement relevant earthing systems.

## 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 | - | 4 | 6 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 50@ | 20 | 50 | 20 | 100 | 40 |

*(*): 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 different electrical safety accessories and practices. | I* | 2 |
| 2. | Use different types of electrical/electronic tools. | I* | 2 |
| 3. | Test the working of the given components: i) single pole one way and two way switches and ii) MCB using relevant tools and instruments. | I* | 2 |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. required |
|---|---|---|---|
| 4. | Test the working of the given components: i) RCB and ii) ELCB using relevant tools and instruments. | I* | 2 |
| 5. | Measure conductor resistance of cables using Kelvin's double bridge. | II* | 2 |
| 6. | Use the Megger to measure insulation resistance of cables. | II* | 2 |
| 7. | Use the Wheatstone's bridge to measure resistance of a conductor bundle (to determine per unit length resistance). | II* | 2 |
| 8. | Use Wheatstone's bridge to measure resistance of conductor bundles (to determine per unit length resistance) (two specimens of different cross sections area). | II* | 2 |
| 9. | Select and place relevant fuses in different lighting circuits. | II* | 2 |
| 10. | Use the coil over core arrangement to determine the iron losses per unit weight of first electromagnetic specimen. | II^ | 2 |
| 11. | Use the coil over core arrangement to determine the iron losses per unit weight of second electromagnetic specimen. | II^ | 2 |
| 12. | Select insulating materials for specific applications from given samples(at least five). | III* | 2 |
| 13. | Investigate (and record observations) a cable failure by insulation breakdown (1st case). | III* | 2 |
| 14. | Investigate (and record observations) a cable failure by insulation breakdown (2nd case). | III* | 2 |
| 15. | Dielectric strength test of one insulating oil sample. | III* | 2 |
| 16. | Dielectric strength test of two different insulating oil samples of varied usages. | III* | 2 |
| 17. | Prepare staircase wiring and test it. | III* | 2 |
| 18. | Prepare godown wiring and test it. | III* | 2 |
| 19. | Prepare switch board containing four switch four socket arrangements (with fuse, indicator, internal wiring etc.). | III* | 2 |
| 20. | Prepare fluorescent tube light fixture wiring and test it. | III* | 2 |
| 21. | Perform cable laying from incoming bus to a machine installation. | III* | 2 |
| 22. | Cable from incoming main to a residential unit. | III@ | 2 |
| 23. | Trace laid down cables and identify the path. | III@ | 2 |
| 24. | Prepare cable joints (different joints). | II# | 2 |
| 25. | Perform lug crimping for cable leads of a specific size. | II# | 2 |
| 26. | Perform lug crimping for cable leads of a size other than above. | II# | 2 |
| 27. | Perform compound filling and water proof taping of cable joint | II# | 2 |
| 28. | Perform plate earthing for a machine laboratory. | V$ | 2 |
| 29. | Perform plate earthing for a computer centre. | V$ | 2 |
| 30. | Perform plate earthing for a building. | V$ | 2 |
| 31. | Test / measure earthing system resistance of a computer centre. | V$ | 2 |
| 32. | Test / measure earthing system resistance of a building. | V$ | 2 |
| | **Minimum number of practicals: 24** | | |
| | **Total** | | **64 hours** |

***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 24 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:*

| | |
|---|---|
| # | Minimum one practical to be performed |
| & | Minimum one practical to be performed |
| @ | Minimum one practical to be performed |
| ^ | Minimum one practical to be performed |
| $ | Minimum one practical to be performed |

| S. No. | Performance Indicators | Weightage in % |
|---|---|---|
| 1 | Plan (draw) the wiring circuit. | 20 |
| 2 | Use of the relevant wiring tools. | 20 |
| 3 | Follow safety practices. | 20 |
| 4 | Timely submission of work. | 20 |
| 5 | Answers to sample questions. | 20 |
| | **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. Practice good housekeeping with safety measures.
b. Demonstrate working as a leader/a team member.
c. Maintain tools and equipment.
d. 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
- 'Organising Level' in 2nd year and
- 'Characterising Level' in 3rd year.

## 7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| 1 | Pliers, nose pliers, cutter cum insulation remover, screw driver, tester, test | Common |

| S. No. | Equipment Name with Broad Specifications | PrO. No. |
|---|---|---|
| | lamp, crimping tool, lugs, continuity tester, wire gauge, knife, safety hand gloves, safety boots, safety goggles , safety rubber mats (ISI Mark). | to all |
| 2 | Exhaustive samples of wires/wire bundles (as per standard table), samples of non-armoured and armoured cables, MCB/ELCB/RCB. Single pole one way and two switches, fluorescent tube circuit, ceiling roses, switch boards, casing-capping strips, PVC and iron conduits, lugs, different types of fuses earthing equipment and all other wiring components for LT electrical installation system. | 3, 4, 9, 13, 14, 17 to 27 |
| 3 | Test lamps suitable for 250 V and 400V. | Common to all |
| 4 | Line tester. | Common to all |
| 5 | Clamp-on meter/Tong Tester 0 – 50A (digital or analog). | Common to all |
| 6 | Megger 500 V,(digital or analog). | Common to all |
| 7 | Multimeter: Frequency: 0.1Hz ~ 30MHz, DC Voltage: 0.1mV ~ 1000V AC Voltage: 0.1mV ~ 750V, approximate resistance range: 0 to 100 M.Ohms (digital or analog). | Common to all |
| 8 | Exhaustive samples of insulations, insulating oils and damaged cables. | 12 to 16 |
| 9 | Electromagnetic stampings laminated electromagnetic cores (assembled) with suitable coils placed over them for iron losses measurement. | 10, 11 |
| 10 | LPF wattmeters up to (250 V, 0 to 2 A, 5A depending on capacity of above core/coil). | 10, 11 |
| 11 | Wheatstone bridge, Kelvin's double bridge. | 5, 7, 8 |
| 12 | Plate earthing sets as per IS norms / IE rules. | 28 to 32 |

## 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 Wiring components, tools and safety devices** | 1a. Explain safety rules/ standards in the given electrical systems.<br>1b. Describe the use of the given tools in the given electrical engineering situation<br>1c. Explain the use of the given safety accessories in the given electrical engineering situation.<br>1d. Explain the functions/applications of the given components of wiring. | 1.1 IE rules of safety.<br>1.2 Safety Tools used in wiring: Pliers, nose pliers, cutter cum insulation remover, screw driver, tester, test lamp, crimping tool, continuity tester, wire gauge, knife.<br>1.3 Accessories: safety hand gloves, safety boots, safety goggles , safety rubber mats.<br>1.4 Components with specifications used in wiring systems: different types of iron clad switches, DBs, switches, plugs, sockets, MCBs, |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | | RCBs, ELCBs, holders, wires, cables. |
| **Unit– II Conductors and electromagnetic materials** | 2a. Describe the salient features of the given type of conductor with respect to the needed functional properties.<br>2b. Explain with justification the applications for the given electrical conductors in specified situations.<br>2c. Describe the salient features of electromagnetic materials in the given electrical engineering situation.<br>2d. Describe with justification the use of various magnetic materials in the given electrical engineering situation. | 2.1 Properties of conducting materials: electrical, mechanical and thermal properties of conducting materials.<br>2.2 Conducting materials and their applications: copper, aluminium, tungsten, brass, bronze, mercury, silver, lead, nickel and tin).<br>2.3 Types of magnetic materials: Ferromagnetic, paramagnetic and diamagnetic materials.<br>2.4 Properties and applications of magnetic materials: Magnetization curve. hysteresis, hysteresis loss, magneto-striction, materials, C. R. G. O. silicon Steel, H. R .G. O. silicon steel, typical hysteresis loops for different ferromagnetic materials (hard steel, wrought iron and alloyed steel), Loss of magnetism. |
| **Unit– III Electrical insulating materials.** | 3a. Describe the properties of the given electrical insulating materials.<br>3b. Classify the given insulating material-with examples of gaseous, liquid and solid insulators.<br>3c. Describe the failure phenomena in the given type of insulating material(s).<br>3d. Suggest relevant insulating material(s) for given application(s) with justification. | 3.1 Significance and properties of electrical insulating materials: electrical, mechanical and thermal properties.<br>3.2 Thermal classification of insulators, classes of insulators.<br>3.3 Dielectric failure of insulating materials. (Gaseous, Liquid & Solid state).<br>3.4 Applications of insulating materials in electrical machines and devices. |
| **Unit– IV Electrical wiring** | 4a. Explain with justification the criteria for selecting wire/cable and other electrical components for the given type of installation.<br>4b. Describe with sketches the installation of wiring systems for the given type of occupancy.<br>4c. Describe with sketches the wiring type as per the functional requirements of the given type of occupancy. | 4.1 Types of wires and cables, components and accessories of electrical wiring systems.<br>4.2 Electrical Wiring systems (such as casing and capping etc.).<br>4.3 Electrical Wiring types (one lamp control, staircase and godown)<br>4.4 Cable laying, Cable joints (terminations), proper size lugs, crimping of joints. |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | 4d. Explain the process of installing the given type of cable(s). | |
| **Unit-V Earthing systems.** | 5a. Recommend with justification the necessity of the type of earthing in the given electrical installation system(s).<br>5b. Explain the criteria for recommending the earthing system for the given electrical installation.<br>5c. Describe with sketches the installation of the given earthing system.<br>5d. Describe the testing procedure for the given earthing systems. | 5.1 Types of earthing systems.<br>5.2 Installation of earthing systems.<br>5.3 Testing/ measurement of earthing resistance for various installations as per IE rules.<br>5.4 Significance and adverse effects of improper earthing systems |

***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 | Wiring components, tools and safety devices. | 08 | 02 | 04 | 08 | 14 |
| II | Conductors and electromagnetic materials | 12 | 04 | 04 | 06 | 14 |
| III | Electrical insulating materials. | 10 | 02 | 06 | 08 | 16 |
| IV | Electrical wiring | 10 | 02 | 04 | 08 | 14 |
| V | Earthing systems. | 08 | 02 | 04 | 06 | 12 |
| **Total** | | **48** | **12** | **22** | **36** | **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. Collect from market the catalogues of electrical engineering materials such as conductors and insulators.

b. Collect from internet or otherwise information on the different electromagnetic materials along with the forms in which they are available.
c. Trace the connection diagram of control circuit of any equipment in the electrical laboratory.
d. Make the list of manufacturers of wiring components and accessories.
e. Make the list of manufacturers and suppliers of light fittings.
f. Collect the information of substation earthing.

## 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. Show video demonstration on safety precautions while working in electrical environment.
g. Demonstrate the actions and care to be taken in case of electrical accidents.
h. Arrange a visit to appliances/wire manufacturing unit / transformer or coil manufacturing unit/electrical shops / workshops.
i. Arrange expert lecture of industry person in the area of electrical safety.

## 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. Draw labeled lighting circuit diagram, list the accessories used with their specifications and complete wiring work of following simple electrical circuits on test board with appropriate testing under guidance of supervisor / teacher
b. Circuit consists of suitable MCB, one lamp holder, one indicator, one 5 A five pin socket and two 5A single pole switches.

c. Circuit consisting of suitable MCB, one call bell, one indicator, one lamp control from two places, three switches [Two switches are two way controlled] (all for 5A rating)
d. Circuit consisting of relevant MCB, 15A single pole switch, one indicator, one 5 pin 15A power socket.
e. Prepare series test board containing one lamp, one indicator, one socket for 230 V operations.
f. Latest techniques in cabling and wiring.

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Electrical Engineering Drawing | Bhattacharya S. K. | New Age International, New Delhi, 2013, ISBN: 978-81-224-0855-3. |
| 2 | Electrical Wiring, Estimating and Costing | Uppal S.L; Garg G.C. | Khanna Publishers, New Delhi, 2013, ISBN-13: 978-81-7409-240-3. |
| 4 | Electrical Workshop | Singh R.P. | I.K. International Publishing House , Pvt. Ltd. New Delhi 2012, ISBN:9789381141205. |
| 5 | Electrical Estimating and Costing | Gupta J. B. | S. K. Kataria & Sons, New Delhi,2012, ISBN:978-93-5014-279-0 |

## 14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.nsc.org.in/
b. www.esfi.org/
c. www.osha.gov/Publications/electrical_safety
d. www.nfpa.org/safety
e. www.electrical4u.com