Maharashtra State Board of Technical Education, Mumbai

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

Program Name : Diploma in Electrical Engineering / Diploma in Electrical Power System / Diploma in Electrical & Electronics (Power System)

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

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

Semester : Sixth **Scheme : I**

S. N.	Course Title	Course Abbrev iation	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	Maintenance of Electric Equipment	MEE	22625	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
2	Utilization of Electrical Energy	UEE	22626	4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Electrical Estimation and Contracting	EEC	22627	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
4	Emerging Trends in Electrical Engineering	ETE	22628	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
	Elective – II (Select Any One)																				
5	Industrial Drives and Control (EE/EU)	IDC	22629	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Power System Operation and Control (EP)	PSO	22632	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Electric Substation Practices (EE/EP/EU)	ESP	22633	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
6	Capstone Project - Execution and Report writing	CPE	22060	-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40	100
			Total	**16**	**-**	**12**	**28**	--	**350**	--	**150**	--	**500**	--	**150**	--	**150**	--	**300**	--	**800**

Student Contact Hours Per Week: **28 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.**

MSBTE – Final Copy Dt. 24.09.2019

Program Name : **All Branches of Diploma in Engineering and Technology.**

Program Code : **CE/CR/CS/CH/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/ MU/EE/EP/EU/IS/IC/AE/FG/ME/PG/PT/DC/TX/TC**

Semester : **Sixth**

Course Title : **Capstone Project – Execution & Report Writing**

Course Code : **22060**

1. RATIONALE

This course on 'Capstone Project–Execution and Report Writing' is the continuation of the previous semester course on 'Capstone Project–Planning'. So, in this semester, the students are to implement the detailed Capstone Project Plan, which they have prepared in the preceding semester. Therefore, to successfully complete this Capstone Project by the end of this semester, it is necessary to incorporate the suggestions of the guide/examiners of the preceding semester. Hence, it is of utmost importance for the student to again re-capitulate and comprehend the importance, concept and need of the 'Capstone Projects' which are well explained in the 'Capstone Project–Planning' course in the previous semester.

Often, the jobs in the industry, which the diploma holders will come across when they join it and will be in the form of small or large projects. Such projects are generally an integration of the various types of skills which cut across the three major domains of learning i.e. cognitive, psychomotor and affective domain which must have acquired during their journey from first semester to the last semester. Hence, it is essential that students are also given an opportunity to do large projects which require more time compared to the micro-projects in order to develop and integrate the highly essential industry oriented competencies and associated skills in the students. Therefore, in this semester the 'Capstone Project – Execution and Report Writing' will continue to integrate some more additional competencies along with those in the previous semester and hence build up greater confidence to face such situations in the world of work.

2. COMPETENCY

The course should be taught and implemented with the aim to develop the required course outcomes (COs) so that students will acquire following competency needed by the industry:

- **Implement the Capstone Project Plan to solve the identified problem/task faced by industry/user related to the concerned occupation by integrating the various types of skills acquired during the programme.**

3. COURSE OUTCOMES (COs)

Depending upon the nature of the projects undertaken, the following could be some of the major course outcomes that could be attained, although, in case of some projects few of the following course outcomes may not be applicable.

a) Implement the planned activity individually and/or as team.
b) Select, collect and use required information/knowledge to solve the identified problem.
c) Take appropriate decisions based on collected and analysed information.
d) Ensure quality in product.
e) Incorporate energy and environment conservation principles.
f) Consider the ethical issues related to the project (if there are any).
g) Assess the impact of the project on society (if there is any).
h) Communicate effectively and confidently as a member and leader of team.

i) Prepare project report after performing due plagiarism check using appropriate tools.

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	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. Course details

As the implementation of the Capstone project progresses and which has to be submitted at the end of project work, one of the outputs of this course is a detailed ***Project Report*** that is continuously prepared by the student. There will also be regular progressive assessment by the teacher as per the criteria no 7 on the basis of rubrics mentioned in **Appendix –C** and in the formats as shown in **Appendix-B** and also for the end-of-semester examination.

5.1 Guidelines for Capstone Project–Execution and Report Writing

a) The students would like to revise the 'Capstone Project – Plan' based on the feedback received in the fifth semester examination.

b) This revised 'Capstone Project – Plan' would be again approved by the project guide. As soon as the revised plan is approved by the teacher, the student will begin to work according to it and would also continue to maintain a dated ***'Project Diary'*** for the whole semester. This is a sort of a 'weekly diary' indicating all the activities conducted by the student every week in the semester to complete the project. This 'Project Diary' should be got signed by the teacher at regular intervals for progressive assessment. If this is maintained sincerely and truthfully by the student, it will be very helpful in compiling the ***Final Project Report*** at the end of the semester by him/her.

6. Project report

During the final Semester, the student will prepare a 'Project Report' in continuation with the activities conducted in fifth semester under Project Planning having following sub-titles:

Suggested contents of the Project report

- Title page (with name of team members and mentor teacher)
- Certificate (in the Format given in this document as annexure A)
- Acknowledgements (this may need revision at the end of the final semester)
- Abstract (in one paragraph not more than 150 words)
- Content Page

Chapters

1. Chapter–1 Introduction (background of the Industry or User based Problem/Task)
2. Chapter–2 Literature Survey (to finalise and define the Problem Statement)
3. Chapter–3 Scope of the project
4. Chapter–4 Methodology
5. Chapter-5 Details of designs, working and processes

6. Chapter-6 Results and Applications
7. Chapter-7 Conclusions And future scope
8. Appendix (if any)
9. References and Bibliography

Note:

i. The report should contain as many diagrams, figures and charts etc as relevant for the project.
ii. Originality of the report (written in own words) would be given more importance rather than quality of printing and use of glossy paper or multi-colour printing

7. ASSESSMENT OF PROJECT WORK

Project work has two components, first is Progressive Assessment (PA), while another is End Semester Examination (ESE).

7. 1. Progressive Assessment (PA) Guidelines and Criteria

Project guide is supposed to carry out this assessment. It is a continuous process, during which for developing desired qualities in the students, faculty should orally give **informal feedback** to students about their performance and interpersonal behaviour while guiding them on their project work every week. Following criteria should be considered while assessing students informally or formally during different stages of the project work.

The following factors need consideration for both Capstone Project-Planning and Capstone Project-Execution and Report Writing.

a) Students should be assessed during the project work so that students can also get feedback for further improvement.
b) It should be kept in mind that project work is mainly experiential learning and it is not the research work, so emphasis should be on work based learning or learning from experience and development of attitudes and skills as mentioned in course outcomes. So focus of assessment should also be on learning from the process of completing project work rather than on novelty or innovation in the project work.
c) For progressive assessment at the end, students should be asked to give the power point presentation before group of teachers and junior students (so that junior students may also get awareness about the major project work they have to carry out in future)
d) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks if they have done enough efforts.)
e) The students would not be awarded marks if they have completed the project by getting done the work from market or some professionals (taking some help and guidance is different as compared to getting the work or maximum part of the work completed from others on payment basis).
f) Originality of the report (written in own words) would be given more importance.
g) The Project Guide will assure the quality of project done by his group.

Criteria of Marks for PA for Capstone Project -Execution and Report Writing.

S. No.	Criteria	Marks
1	**Project Proposal /Identification**	10
2	**Punctuality and overall contribution**	
3	**Project Diary**	
4	**Execution of Plan during sixth semester**	20
5	**Project Report including documentation**	15
6	**Presentation**	05
	Total	**50**

7.2 END SEMESTER EXAMINATION (ESE)

Evaluation shall be carried out according to following criteria. For each project, students from the concerned group should be asked to make presentation of their project , in front of the external and internal examiners which should be followed by question answer session to ascertain the contribution made by each student.

Criteria of Marks for ESE for Capstone Project -Execution and Report Writing

S. No.	Criteria	Marks
1	Project Proposal	05
2	Punctuality and overall contribution	
3	Project diary	
4	Execution of Plan during sixth semester	10
5	Project Report including documentation	10
6	Presentation	10
7	Question and Answer	15
	Total	**50**

8. SPECIAL TEACHING STRETAGIES (If any)

a) Teacher's should not spoon feed the students and let them try on their own at different stages of the project work and even first let them strive hard and only when efforts of students have failed, then teacher should guide them. Guidance should be in initially in the form of clues or hints rather than complete explanation, detailed explanation should be given only when students are not able to work based on clues/hints. The role of teacher should be limited to guide and facilitator

b) Teachers should help students in selecting a topic which is relevant and challenging (but within capacity) for students according to their abilities.

c) ***Teachers should come out of the mindset that there should be compulsorily some innovation and novelty in the project work. Because as discussed earlier, project is mainly opportunity for work based or experiential learning, the aim of which is to develop higher order cognitive skills and attitudes. Project at diploma level is not research or innovation.*** The main thing teachers have to ensure is that students choose a task or problem for their project work which is challenging but according to their capability i.e. a task which they can complete on their own without getting it done from market.

d) Teachers should ensure that students prepare the project plan in as much detail as possible, since this way only they would learn the importance of planning and how to do the detail planning. Teachers should allow students to proceed ahead only when they have detailed plan with them.

e) Teachers should motivate students to maintain project document project diary and project report. They should explain benefits of these activities to students and also train them in these activities, because most of them may be doing this first time.

f) Project Guide should ensure that students submit chapter of report one by one to him/her as per schedule and should check the content of the chapters. The Project guide should monitor that schedule is maintained and report writing is not left till last few weeks. It should not be a problem since first three chapters of the report should have been written in fifth semester itself.

g) Teachers should also encourage students to openly discuss their weaknesses and shortcomings .Teachers should develop confidence in students that admitting mistakes and weaknesses helps in improving them.

h) Teachers should continuously discuss with students about working of group and progress in the project and from this discussion should identify their personal qualities (both strengths and weaknesses) and suggest to them ways for improving those qualities.

i) Internal as well as external examiners should reward students for original work and efforts of students even if they are not fully successful or not able to complete the project in comparison to those students who have taken paid help from others to complete their project.

Appendix–A

CERTIFICATE

This is to certify that Mr./Ms.....

from .....Institute having Enrolment No: .....

has completed project of final year having title .....,.... during the academic year20__-20__. The project completed by individually/ in a group consisting of..... persons under the guidance of the Faculty Guide.

.....

.....

Name & Signature of Guide: .....

Telephone:.....

Appendix–B

PROGRESSIVE ASSESSMENT (PA) OF CAPSTONE PROJECT – EXECUTION AND REPORT WRITING

Evaluation Sheet for Internal Assessment

Name of Student: .....
Name of Programme..... **Semester: Sixth**
Course Title: Capstone Project : Execution and Report Writing **Code:22060.**
Title of the Capstone Project: .....
.....

A. **POs addressed by the Capstone Project** (Mention only those predominant POs)

a) .....
b) .....
c) .....
d) .....

B. **COs addressed by the Capstone Project** (Mention only those predominant POs)

a) .....
b) .....
c) .....
d) .....

C. **OTHER LEARNING OUTCOMES ACHIEVED THROUGH THIS PROJECT**

1. **Unit Outcomes (Cognitive Domain)**
   a) .....
   b) .....
   c) .....
   d) .....

2. **Practical Outcomes (in Psychomotor Domain)**
   a) .....
   b) .....
   c) .....
   d) .....

3. **Affective Domain Outcomes**
   a) .....
   b) .....
   c) .....
   d) .....

PROGRESSIVE ASSESSMENT (PA) Sheet		
S. No.	**Criteria**	**Marks**
1	Project Proposal /Identification	10
2	Punctuality and overall contribution	
3	Project Diary	
4	Execution of Plan during sixth semester	20
5	Project Report including documentation	15
6	Presentation	05
Total		**50**

Appendix–B

Suggested Rubric for Capstone Project – Execution and Report Writing

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent
1	**Problem/Task Identification (Project Title)**	Relate to very few POs Scope of Problem not clear at all	i. Related to some POs ii. Scope of Problem/Task vague	i. Take care of at-least Three POs ii. Scope of Problem/task not very specific	• Take care of more than three POs ii. Scope of problem/task very clear
2	**Literature Survey /Industrial Survey**	Not more than ten sources (primary and secondary), very old reference	At-least 10 relevant sources, at least 5 latest	At –least 15 relevant sources, most latest	About 20 relevant sources, most latest
3	**Project proposal**	Methods are not appropriate, All steps not mentioned, Design of prototype not started (if applicable).	Appropriate plan but not in much detail. Plan B for critical activities not mentioned. Time line is not developed. Design of Prototype is not complete. (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, but clarity is not there in methods, time line is given but not appropriate. Design of prototype is not detailed (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, clarity in methods with time line, Detailed design of prototype (if applicable)
4	**Project Diary**	Entries for most weeks are missing. There is no proper sequence and details are not correct.	Entries for some weeks are missing, details are not appropriate, not signed regularly by the guide.	Entries were made every week but are not in detail. Signed and approved by guide every week	Entries were made every week in detail, signed and approved by guide every week
5	**Final Report Preparation**	Very short, poor quality sketches, Details about methods, material, precaution and conclusions	Detailed, correct and clear description of methods, materials, precautions and	Conclusions. Sufficient Graphic Description.	Very detailed, correct, clear description of methods, materials, precautions and conclusions. Enough tables,

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent
		omitted, some details are wrong			charts and sketches
6	**Presentation**	Major information is not included, information is not well organized .	Includes major information but not well organized and not presented well	Includes major information and well organized but not presented well	Well organized, includes major information ,well presented
7	**Defense**	Could not reply to considerable number of question.	Replied to considerable number of questions but not very properly	Replied properly to considerable number of question.	Replied to most of the questions properly

Appendix C

Suggestive Project Diary format

Week no:
Activities planned:
Activities Executed:
Reason for delay if any
Corrective measures adopted
Remark and Signature of the Guide

Program Name : **Electrical Engineering Program Group**

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

Semester : **Sixth**

Course Title : **Maintenance of Electrical Equipment**

Course Code : **22625**

1. RATIONALE

The electrical engineering technologist is required to carry out the maintenance of the electrical machines and equipment, which includes installation and testing. S/he is thus expected to use the relevant skill-sets while working in the industry, commercial establishments, and public utility departments such as PWD, irrigation, electricity supply agencies, water supply and sewage board. This course arms the student with the skills to inspect various types of installations and test electrical machines as per prevailing standards. S/he will also be able to carry out different types of maintenances of electrical equipment. S/he will follow the relevant safety practices during such activities.

2. COMPETENCY

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

- **Maintain different types of electrical equipment 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 to prevent accidents while using electrical equipment.
b) Prepare maintenance schedules for electrical equipment.
c) Maintain rotating electrical machines.
d) Maintain single phase and three phase transformers.
e) Maintain insulation systems of electrical equipment.

4. TEACHING AND EXAMINATION SCHEME

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

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *-Practical;* ***C*** *– Credit,* ***ESE*** *-End Semester Examination;* ***PA*** *- Progressive Assessment*

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

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

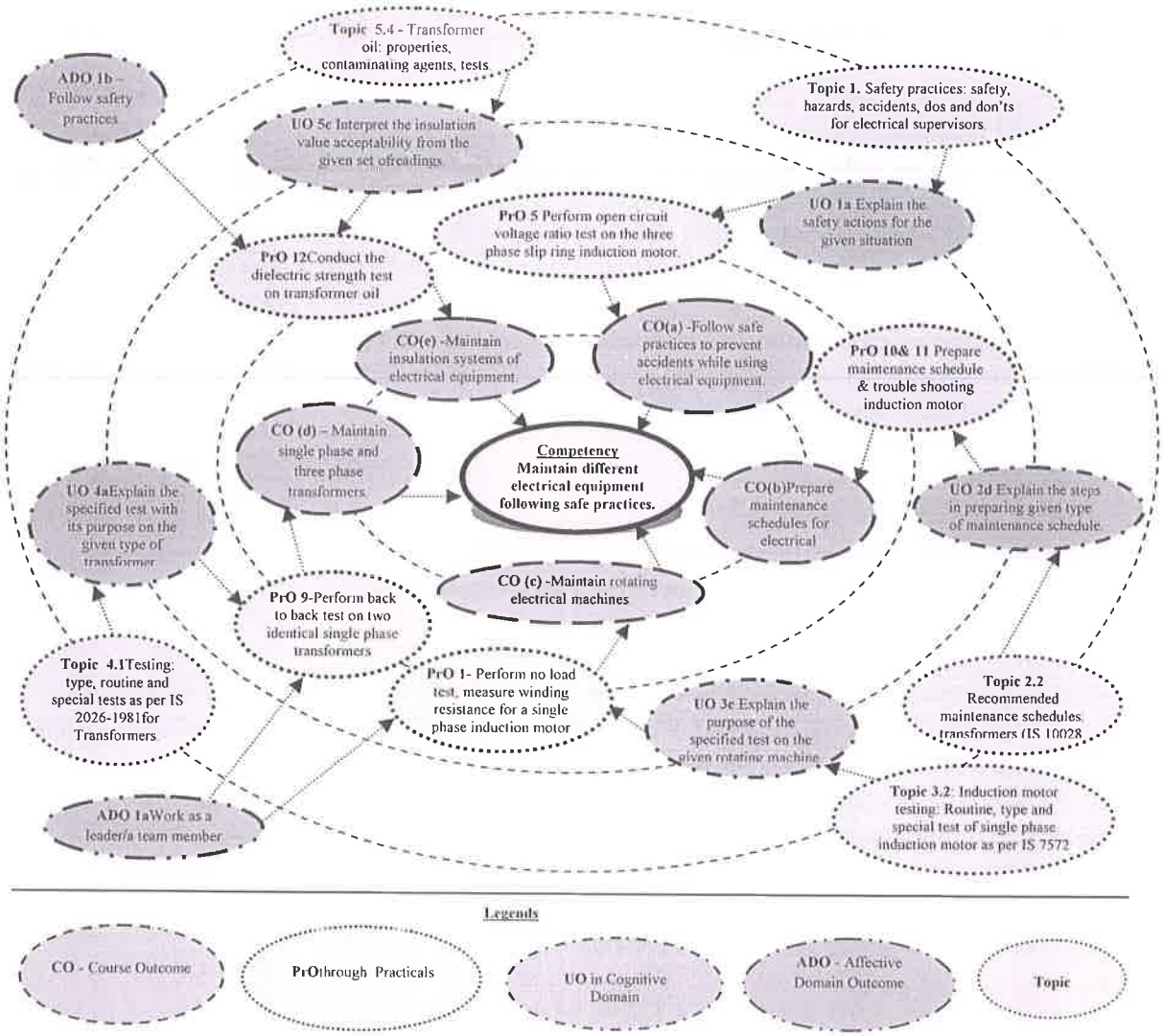

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Perform the no load test, measure winding resistance for a single phase induction motor and determine its performance. (as per relevant IS)	III	02*
2	Perform no load and blocked rotor test on three phase induction motor to determine the equivalent circuit. (as per relevant IS)	III	02*
3	For the motor tested in practical at S. no. 2 plot the circle diagram and judge its performance. (as per relevant IS)	III	02*
4	Perform the brake load test on the three phase Induction motor	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	to plot the following operating characteristics, [(1) torque versus speed, (2) current drawn versus output and (3) power factor versus output] (as per relevant IS)		
5	Perform open circuit voltage ratio test on the three phase slip ring induction motor. (as per relevant IS)	III	02*
6	Perform the phasing out and polarity tests on the three phase transformer. (as per relevant IS)	IV	02*
7	Perform the open circuit and short circuit tests on the single phase transformer and determine its performance (regulation and efficiency). (as per relevant IS)	IV	02#
8	Perform the open circuit and short circuit tests on the three phase transformer and determine its performance (regulation and efficiency). (as per relevant IS)	IV	02#
9	Perform back to back test on two identical single phase transformers and determine their efficiencies and regulations.	IV	02*
10	Prepare the maintenance schedule for trouble shooting chart for the single phase induction motor. (as per relevant IS)	II/III	02^
11	Prepare the maintenance schedule for trouble shooting chart for the three phase induction motor. (as per relevant IS)	II/III	02^
12	Prepare maintenance schedule for trouble shooting chart for 3ph Transformers. (as per relevant IS)	II/IV	02*
13	Conduct the dielectric strength test on transformer oil (sample 1). (as per relevant IS)	V	02 &
14	Conduct the dielectric strength test on transformer oil (sample 2). (as per relevant IS)	V	02 &
15	HV test on three phase induction motor (as per relevant IS)	III/V	02%
16	HV test on single phase induction motor. (as per relevant IS)	III/V	02%
	Total		**32**

Legend: #: any one to be performed; &: any one to be performed, %: any one to be performed, ^: any one to be performed,

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 practicals 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	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
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

S. No.	Performance Indicators	Weightage in %
	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) Work as a leader/a team member.
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
- 'Organisation Level' in 2nd year
- 'Characterisation 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 administrators.

S. No.	Equipment Name with Broad Specifications	PrO.No.
1	230 V, 50 Hz, single phase capacitor start cage type induction motor (suitable available HP)	1
2	3-phase 5 HP, 400 V, 50 Hz, 1500 RPM squirrel cage induction motor with brake load arrangement as required.	2, 3, 4
3	400V/230V, 50 Hz, 3-phase transformer with all phase winding terminals brought out for connections (suitable output in range of 2 kVA to 4 kVA)	8
4	3-phase 400V, 50 Hz, 1500 RPM slip ring induction motor about 5 HP.	5
5	At least two identical 230 V/115 V or 400 V/ 230 V 50 Hz, 1 or 2 kVA single phase transformers.	6, 7, 9
6	Dielectric oil testing kit (with input at 230 V)	12, 13
7	HV test kits for motors up-to 400 V.	14, 15, 16
8	AC Ammeter range (0-2.5-5-10A), Portable analog MI type as per relevant BIS standard	1, 2, 4, 5, 7, 8, 9
9	AC Voltmeter Range (0-75/150/300V, 0 - 300V /600 V), Portable analog MI type as per relevant BIS standard.	1, 2, 4, 5, 7, 8, 9
10	Tachometers 0-5000 RPM minimum	1, 2, 4
11	Single phase auto transformer 0-270 V, 15 A, input single phase, 230 V.	1, 6, 7, 9
12	Three phase auto transformer 0-450 V, 15 A, input 3 phase, 400 V.	2, 4, 5, 8
13	A. C Watt meters: 0-300/600 V, 5/10 A or 10/20 A as needed.	1,2,4,7, 8, 9
14	LPF Wattmeter, 0-300/600 V, 1A to 2A.	1, 2, 7, 8, 9

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 (in cognitive domain)	Topics and Sub-topics
Unit – I Safety and prevention of accidents	1a. Explain the safety actions for the given situation. 1b. Explain the hazards involved for the given situation and action. 1c. Explain the responsibilities of the supervisor in the given hazardous or accident situation. 1d. Explain the level of accountability of the supervisor in the given hazardous or accident situation 1e. Explain the monitoring actions to be taken by the supervisor while working in the given hazardous or accident situation 1f. State the principal characteristics and related precautions for safety of equipment earthed by the specified class.	1.1 Safety practices: safety, hazards, accidents, dos and don'ts for electrical supervisors. 1.2 Electric shock: factors influencing severity of shock, rescuing persons, procedures for artificial respiration. 1.3 Precautions against electric fires, use of fire extinguishers, actions in case of such fires, types and operation of fire extinguishers. 1.4 Earthing of electrical equipment {refer IS code IS 3043-1987):Objectives, classification of electrical equipment with regard to protection against electric shock: class 0 to III.
Unit – II Maintenance schedules	2a. Explain the need for maintenance for the given type of electrical equipment. 2b. Explain the relevant type of maintenances required for the given type of electrical equipment. 2c. Explain the advantages of the given type of maintenance. 2d. Explain the steps in preparing given type of maintenance schedule.	2.1 Maintenance: routine, breakdown, preventive and predictive maintenance, factors affecting preventive maintenance schedules. 2.2 Recommended maintenance schedules: transformers (IS 10028, part III – 1981);single phase and three phase induction motors (IS 900 – 1992); three phase alternators and synchronous motors.
Unit- III Testing and Maintenance of rotating machines	3a. Explain the objectives of testing the given type of electrical machine. 3b. Explain the need for the given type of test/s on the specified machine. 3c. Explain the purpose of the specified test on the given type of rotating machine. 3d. Explain the steps in preparing trouble shooting chart for the given type of rotating machine. 3e. Explain the steps in preparing foundation for the given type of rotating machine. 3f. Explain with sketch the foundation for the given type of rotating machine.	3.1 Testing: Need and standards, tolerance, types: routine, type, special and supplementary tests, Methods of testing: direct, indirect and regenerative with advantages and applications. 3.2 Induction motor testing: Routine, type and special test of single phase induction motor as per IS 7572 – 1974 (re-affirmed in 2002) and three phase induction motor as per IS4029 -2010. 3.3 Alternator and synchronous motor testing: Routine, type and special test of three phase alternator and synchronous motor as per IS 7132 1973 (reaffirmed in 2002).

	3g. Suggest the tools for the given operation under maintenance of the rotating machine.	3.4 Trouble shooting chart for single phase and three induction motor (IS 900 – 1992). 3.5 Foundations: Requirements and factors affecting rotating machine foundation. 3.6 Tools/instruments: Bearing puller, filler gauge, dial indicator, spirit level, megger, earth tester, growler, test lamps, multimeter, spanner sets, and screwdrivers.
Unit– IV Testing and trouble shooting of Transformers	4a. Explain the specified test with its purpose on the given type of transformer. 4b. Explain the causes of failure of the specified type of transformer from the given symptoms. 4c. Explain the steps in preparing trouble shooting chart for the given type of transformer. 4d. Explain the remedies for the specified fault in the given transformer. 4e. Suggest the foundation with sketch for the given type of transformer.	4.1 Testing: type, routine and special tests as per IS 2026-1981 for Distribution and Power transformers. 4.2 Causes of failure: internal and external, types of faults: mechanical. electrical and magnetic 4.3 Trouble-shooting and remedies: trouble shooting charts for single phase and three phase transformers, 4.4 Foundations: requirements for static machine foundations, factors governing them.
Unit– V Maintenance of Electrical Machine Insulation	5a. Suggest the insulation material for the given application. 5b. Explain with sketch the procedure to measure the insulation resistance of the given type of machine. 5c. Interpret the insulation value acceptability from the given set of readings. 5d. Explain the reasons for weakening of given type of insulation. 5e. Explain with sketch the procedure to strengthen the given insulation. 5f. Describe the procedure to maintain the insulation of the specified electrical machine in healthy condition. 5g. Prepare the sample history for the specified electrical machine.	5.1 Classification of insulating materials as per IS 8504- 1994, 5.2 Factors affecting life of insulating materials. 5.3 Measurement of insulation resistance and interpretation of condition of insulation. 5.4 Transformer oil: properties, contaminating agents, tests. 5.5 Strengthening insulations: weakening agents, cleaning, drying, re-varnishing, baking, impregnation, filtration. 5.6 Measures to be taken to maintain the insulation resistance of electrical machines to healthy levels. 5.7 History sheets of transformers and induction motors: [Part A: machine specifications with component specifications (installation information, bearings, oil type, core weight etc. as applicable). Part B: date wise: observations of parameters such as voltage,

		current, temperature etc., symptoms, works carried out under maintenance)

***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 QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Safety and prevention of accidents	06	02	04	04	10
II	Maintenance schedules	10	02	02	06	10
III	Testing and maintenance of rotating machines	12	04	06	10	20
IV	Testing and trouble shooting of Transformers	12	04	06	10	20
V	Maintenance of electrical machine insulation.	08	02	02	06	10
Total		**48**	**14**	**20**	**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) Prepare report for step by step procedure to be followed for artificial respiration to be given to shock affected person.
b) Carry out preventive maintenance on any one machine in lab and prepare report on it.
c) Prepare power point presentation on testing of Induction motor as per IS.
d) Prepare power point presentation related to foundation of transformers.
e) Collect sample of various class of insulating materials and prepare a chart of it.

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) Use Flash/Animations to explain various theorems in circuit analysis
f) Guide student(s) in undertaking micro-projects.

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.

Suggestive lists of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Collect information on safety signs used for electrically hazardous areas.
b) Prepare a case study report on faulty electrical machine in institute campus through inspection, conduction of tests, troubleshoot and remedial actions needed.
c) Visit electrical machine manufacturing unit and collect data of various tests conducted on it.
d) Prepare a report on diagnosis of transformer oil sample by conducting various tests on it.
e) Collect information of specifications, uses, cost of various tools and equipment needed for maintenance of different electrical machines.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Electrical Machines	Bhattacharya,S. K.	McGraw Hill Education. New Delhi, ISBN : 9789332902855
2	Electrical Technology Vol-II (AC and DC machines)	Theraja, B.L.	S.Chand and Co.Ltd., New Delhi ISBN : 9788121924375
3	Electrical Machines Theory and Practice	Bandyopadhyay, M. N.	PHI Learning Pvt. Ltd., New Delhi, ISBN :9788120329973 Vi
4	IS codes for transformers	IS 2026 (part 1-2011, part 2-2010), IS 10028 (part III) -1981.	
5	IS codes for induction motors	IS 325-1996, IS 4029-2010, IS 900-1992.	
6	Guide for testing of single phase and universal motors	IS 7572 – 1974 (reaffirmed 2002)	

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) https://www.youtube.com/watch?v=w4jHpHoYZhk
b) https://www.youtube.com/results?search_query=artificial+respiration+methods
c) https://www.youtube.com/results?search_query=dielectric+tests+of+transformer
d) https://www.youtube.com/results?search_query=maintenance+charts+for+transformer
e) https://www.youtube.com/watch?v=ntOc4h792UE
f) https://www.youtube.com/watch?v=uMxK6djp_rI
g) https://www.youtube.com/results?search_query=transformer+oil+filtration+procedure
h) www.nptel.ac.in
i) www.wikipedia.com
j) www.electricaltechnology.org
k) www.howstuffworks.com
l) www.electrical4u.com

Program Name : **Electrical Engineering Program Group**

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

Semester : **Sixth**

Course Title : **Utilization of Electrical Energy**

Course Code : **22626**

1. RATIONALE

Electricity is used in every walk of life whether it is home, office, industry or farm. It is being used for lighting, heating, cooking, air conditioning, operating machines/computers, welding, traction, irrigation. Due to power crisis, economical utilization of electrical energy and energy conservation is an essential aspect. Every diploma electrical engineer therefore should know to operate and maintain main electrical utilities for their efficient operations. Essential theoretical and practical knowledge will be achieved by this course.Keeping the above objectives in view, besides giving him basic knowledge in the topics concerned, attempts have been made to ensure that the knowledge acquired is applied in various fields as per his job requirements.

2. COMPETENCY

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

- **Maintain different types of electrical utilities and systems.**

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 functioning of different types of lamps and fittings.
b) Maintain different electric heating and welding equipment.
c) Maintain different electric drives and elevators.
d) Use different electric traction systems.
e) Use equipment for 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*

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.

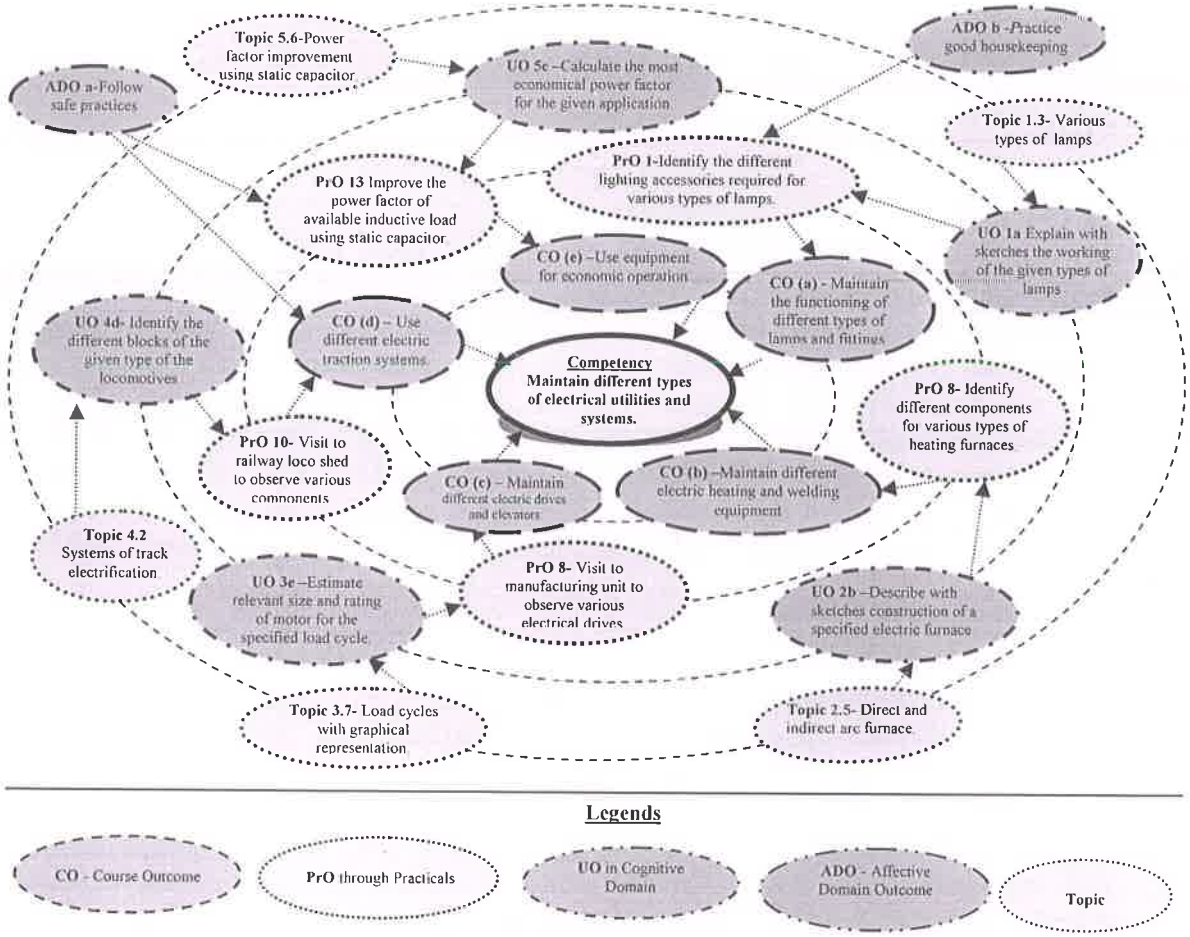

Figure 1 - Course Map

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 different lighting accessories required for various types of lamps.	I	02*
2	Identify the different lighting accessories required for various types of lamp fittings.	I	02
3	Measure illumination at different places in college using luxmeter.	I	02*
4	Identify the different components required for various types heating furnaces	II	02*
5	Observe construction and working of various heating furnaces by watching video programmes.	II	02
6	Identify the different accessories and safety devices required for various types of welding system.	II	02
7	Prepare a report of specification of various electrical welding machines available in college workshop	II	02*
8	Visit a small manufacturing unit to observe various electrical drives and prepare a technical report.	III	02*

S.No	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Prepare a comparative chart of two different manufacturing company in India for any two Lift/Elevator with technical data.	III	02
10	Visit a railway loco shed to observe various components and working of electric locomotive and prepare a technical report.	IV	02
11	Prepare a report /chart on various types of traction systems.	IV	02*
12	Prepare a report/chart on speed time curves.	IV	02
13	Improve the power factor of available inductive load using static capacitor.	V	02*
14	Prepare a report based on comparative study of various tariff structure of Maharashtra.	V	02
15	Prepare Energy Bill based on energy consumption of residence/ Institute	V	02*
16	Prepare a technical report after visiting an industry, various power factor improvement devices used. (otherwise from internet)	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 practical's marked as '*' are compulsory and any 04 of remaining 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	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
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) Work as a leader/a team member.
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
- 'Organisation Level' in 2nd year
- 'Characterisation 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. No.
1	FTL,CFL,LED of different suitable ratings,	01
2	Electric choke, Electronic ballast of different suitable ratings,	02
3	Digital Lux meter (UptoLUX-100K)	03
4	Heating furnace / Oven of suitable ratings	04,05
5	Video programme / internet information on various types of heating furnaces	05
6	Electrical welding machine of suitable rating.	06
7	Video programme / internet information on various types of welding systems	06,07
8	Industry visit / internet information for various types industrial drive	08
9	Video programme / internet information on various types of Elevators	09
10	Loco shed/ Track Electrification system visit for observing components /equipment related to traction	10,11
11	Ammeters MI Type: AC/DC 0-5-10Amp	13
12	Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V	13
13	Wattmeter: Three phase double element 5/10Amp, 250/500V	13
14	Wattmeter: Single phase, single element 2.5/5Amp, 200/400V,	13
15	Dimmer: 1-phase,1kVA,230V	13
16	Dimmer: 3-phase, 5kVA	13
17	Three phase Power factor meters: AC, 415V, 50 Hz , 5-10 Amp	13
18	Load bank: Resistive, 3-phase, 5kW, 415V	13
19	Automatic power factor controller (APFC)	13
20	Video programme /internet information Tariffs electricity calculation	13
21	Clip on meter (amp, volts) digital/analog	13

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught 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 Illumination.	1a. Explain with sketches the working of the given types of lamp (s) 1b. Describe with sketches the construction of the given type of lamp fitting. 1c. Explain with sketches the specified lighting scheme for the given application. 1d. Select the relevant lamp for the specified application with justification.	1.1 Definitions of various illumination terminology- Luminous flux, solid angle, luminous intensity, lux, candlepower, MHCP, MSCP, MHSCP, illumination, lamp efficiency, depreciation factor, maintenance factor, coefficient of utilization, space to height ratio, reflection factor, waste light factor, glare, shadow. 1.2 Laws of illumination: Inverse squares and Lambert's Cosine law. 1.3 Various types of lamps: Low pressure mercury vapour lamps(fluorescent

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	1e. Design simple lighting scheme for the given data. 1f. Describe the procedure to maintain the given type of lamp and fitting.	tube),Compact fluorescent Lamps (C.F.L.), High pressure mercury vapour lamps, Sodium vapour lamps, Metal halide lamps, LED lamps. 1.4 Various lighting schemes: features and application. 1.5 Domestic and industrial lamp fittings. 1.6 Electronic ballast.
Unit– II Electric Heating and welding systems.	2a. Explain with sketches and broad specifications working principle of the specified electrical heating system. 2b. Describewithsketches construction of the specified electric furnace. 2c. Recommend therelevantheatingsystem for the given application with justification. 2d. Design the heating element of the given type of furnace forthe specified data. 2e. Select the relevant welding system for aspecifiedapplication with justification. 2f. Describe the procedure to maintain the given type of heating and welding system.	2.1 Concept of electrical heating, classification of electric heating, modes of heat transfer. 2.2 Direct andindirect resistance heating: workingprincipleandconstruction and applications. 2.3 Requirements of resistance heating element material, methods of temperature control, design of heating element. 2.4 Arc Heating: Working principle,properties of material used for electrode, advantages of graphite electrode over carbon electrode. 2.5 Direct arc furnace and indirect arc furnace:construction and operation, specifications,applications. 2.6 Induction heating: Working principle, applications. 2.7 Direct core type furnace:Constructionand working of horizontal and vertical type. 2.8 Coreless type inductionfurnace: Construction, working and applications. 2.9 Dielectric heating: workingprinciple, and applications. 2.10 Eddy current heating: working principle and applications. 2.11 Types of welding systems:plastic and fusion, classifications of electrical welding system. 2.12 Quality of a good weld, welding defects. 2.13 Resistance welding:spot,seam,butt, projection welding and their working principles and applications. 2.14 Arc welding: working principle, characteristics of arc, factors on which arc length, methods of arc stabilization,types of electrodes, advantages of coated electrode. 2.15 Metal and carbon arc applications. 2.16 Supply requirements;AC welding machines-welding transformer, safety precautions.
Unit-III Electric Drives and	3a. Differentiate the salient features between the given types of electric drives.	3.1 Electric drives: concept,factors governing selection of electric drives (motor).

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Elevators.	3b. Recommend relevant motor for the given application with justification. 3c. Select the relevant enclosure of motor for the given atmospheric condition with justification. 3d. Select the power transmission drive of the electric motor for the given application with justification. 3e. Estimate relevant size and rating of electric motor for the specified load cycles. 3f. Explain with sketches relevant braking system for the given electric motor. 3g. Select relevant elevator machine and electric motor for the specified application with justification. 3h. Describe the procedure to maintain the given electric drive and elevator.	3.2 Types of electrical drives: Individual and group drive, applications. 3.3 Mechanical features of drives: Purpose, types and application of various types of enclosures. 3.4 Transmission of mechanical power: Direct and indirect drive(Belt, Rope, Chain, Gear),Vertical drives and its applications. 3.5 Bearing: Types and applications. 3.6 Size and rating of motor, Definition of standard rating as per IS. 3.7 Load cycles: Concept with graphical representation. 3.8 Load Equalization: Meaning, methods and condition of load equalization. 3.9 Braking : Definition of braking, requirements of ideal braking system, 3.10 Types of electrical braking systems: Plugging, rheostatic (Dynamic) and regenerative braking for D.C. series motor and three phase Induction motor. 3.11 Elevators: Function, application, Types, its motors and safety. 3.12 Factors on which shape and size of car depends. 3.13 Bombay Lift Act 1939. (Latest Amendment).
Unit –IV Electric Traction	4a. Recommend relevant traction system for the given application with justification. 4b. Select the relevant track electrification system for the specified traction services with justification. 4c. Differentiate the salient features between the given types of track electrification system. 4d. Draw the speed-time curvefor the specified electric traction application. 4e. Differentiate between the given types traction services based on the given criteria. 4f. Determine average and schedule speed for the giventraction services. 4g. Describe the procedure to	4.1 Requirements of an ideal traction system, different types of traction system used in India: Electric and diesel electric 4.2 Systems of track electrification: D.C., single phase 25kV A.C., composite system 4.3 Traction mechanics : Block diagram of A.C. electric locomotive and function of each part. 4.4 Traction motors: Desirable characteristics, D.C. series motor, single phase A.C. series motor, chopper controlled motors 4.5 Definition of average and schedule speed, factors affecting schedule speed. 4.6 Speed-time curve: Trapezoidal and quadrilateral speed time curve and its applications. 4.7 Current collecting system: Over head wire and conductor rail system, current

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	maintain the given electric traction system.	collector - pantograph types. 4.8 Traction services: Urban, suburban, main line services. Metro rail and monorail: main features that different them, types of electric motors used, current collectors, speed time characteristics
Unit-V Tariff and Power Factor Improve ment	5a. Select the relevant tariff for the given applications with justification. 5b. Explain with the sketches the relevant method for power factor improvementforthe given load. 5c. Calculate the most economicalpower factor forthegiven application(s). 5d. Describe the procedure to maintain the specifiedpower factor of the system.	5.1 Tariff: Desirable characteristics, types(Flat rate, block rate, KVA maximum demand andTime of Day tariff). 5.2 Power factor: Disadvantage of low power factor, advantages ofimprovedp.f., causes of low p.f.,avoidance of low p.f. without using p.f.improvementdevices. 5.3 Power factor improvement using; static capacitor, most economical power factor,location of power factorimprovement devices from consumer and electrical supply company point of view.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'ApplicationLevel'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	Illumination	08	02	02	04	08
II	Electric Heating and Welding System	18	04	06	08	18
III	Electric Drives and Elevator	16	02	08	08	18
IV	Electric Traction	16	04	06	08	18
V	Tariff and Power factor improvement	06	02	02	04	08
Total		64	**14**	**24**	**32**	**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 any two of the 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 a survey report after collecting technical information of various lamps available in the local market(otherwise from internet).
b) Prepare a report on different luminaries available in the market and collect the technical data
c) Preparing reports based on tutorial practices.
d) Assignments for solving numerical.
e) Identify different types of illumination schemes in the Institute.
f) Note the ratings of various types of welding machines in the Institute workshop.
g) Prepare chart of various electrical equipment used for heating.
h) Seminar on elevators.
i) Seminar on latest electric traction in India.

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) Flash/Animations to explain working of Electric Locomotive and Elevators.
g) Pre-guided visits to, railway stations and elevator manufacturing companytoobserve operation.

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 isgroup-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 she/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 isgiven here. Similar micro-projects could be added by the concerned faculty:

a) **Illumination:** Design suitable lighting scheme for a laboratory or class room.
b) Prepare report on market survey of various types of lamps(specification, manufacturer, application and cost) and do its comparative analysis.
c) **Electric heating:** Prepare power point presentation related to heating furnaces.

d) **Electric welding:** Prepare power point presentation related to welding equipments and accessories.
e) **Electric Drives**: Prepare report on market survey of various drives (specification, manufacturer, application and cost).
f) **Elevators**: Prepare report on market survey of various Lift and Elevator (specification, manufacturer, application and cost) and collect Lift and Elevator Act.
g) **Electric Traction**: Prepare power point presentation related to Electric traction systems in India and its comparative analysis.
h) Prepare a chart of Electric Locomotive and show the various components.
i) **Tariff**: Calculation of electricity bill for their own residence/ Institute.
j) **Power factor Improvement**: Prepare the report on the power factor improvement process in the nearby substation/Institute/Small scale industry.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Art and Science of Utilization of Electrical Energy	Partab, H.	Dhanpat Rai &Sons, New Delhi, 2017, ISBN:9788177001440.
2	Utilization of Electric Power and Electric Traction.	Gupta,J. B.	S. K. Kataria& Sons, New Delhi, 2016, ISBN: 978-9350142585
3	Utilization of Electric Power and Electric Traction	Garg,G. C.	Khanna Publishers, New Delhi, 2016, ISBN-8174091645.
4	Electric Traction	Upadhyay, J. Mahendra,S. N.	Allied Publisher Ltd., New Delhi, Latest edition ISBN-8177640054|9788177640052
5	Fundamentals of Electrical Drives	Dubey,G. K.	Narosa Publishing House. New Delhi, Latest edition ISBN-8173190410, 9788173190414.
6	Principles of Power system	Mehta,V.K.	S.Chand, New Delhi, Latest edition ISBN-9788121924962.
7	Generation and Utilization of Electrical Energy	Sivanagaraju, S. Balasubba Reddy M., SrilathaB.	PearsonEducation, New Delhi, 2016 ISBN-9789332515673
8	Modern Electric Traction	Partab, H.	Dhanpat Rai & Sons , New Delhi, 2016, ISBN: 1234567147206

14. SOFTWARE/LEARNING WEBSITES

a) www.nptel.iitm.ac.in
b) www.howstuffworks.com
c) www.khanacademy.com
d) https://www.youtube.com/watch?v=CoHVA7nr82A
e) https://www.youtube.com/watch?v=7GLiBwgVBLQ
f) https://www.youtube.com/watch?v=fakGLu03jYg
g) https://www.youtube.com/watch?v=fQrZMMWo1mA
h) https://www.youtube.com/watch?v=BDMFsYnTdVI
i) https://www.youtube.com/watch?v=49rH3buD0bc
j) https://www.youtube.com/watch?v=82EFMvYcbN4
k) https://www.youtube.com/watch?v=AAyLKnz4UJY

l) https://www.youtube.com/watch?v=EN2ee15BIyg
m) https://www.youtube.com/watch?v=XdrVwsQIgao
n) https://www.youtube.com/watch?v=F1MM2gjCv7I

IS, BIS and International Codes:

o) IS 1860-1980 code of practice for installation, Operation and maintenance of electric Passenger and goods lifts.
p) IS 3534-1976 Outline Dimensions of Electric Lifts.

Program Name : **Electrical Engineering Program Group**

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

Semester : **Sixth**

Course Title : **Electrical Estimating and Contracting**

Course Code : **22627**

1. RATIONALE

The wiring installations are important aspects of any electrical installations. This course will empower the students with the necessary principles of planning, electrical bylaws, supply system and method of installations. This course will also help the students to work as contractors, an entrepreneur and execute different electrical installations work.

2. COMPETENCY

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

- **Plan electrical installations with their cost estimates.**

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. Interpret various electrical diagrams.
b. Prepare estimate of domestic and commercial electrical installations.
c. Prepare estimate of industrial electrical installations.
d. Prepare estimate of overhead and underground distribution lines.
e. Prepare estimate of public lighting installations.
f. Prepare quotation, tender and other related documents.

4. TEACHING AND EXAMINATION SCHEME

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

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

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

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

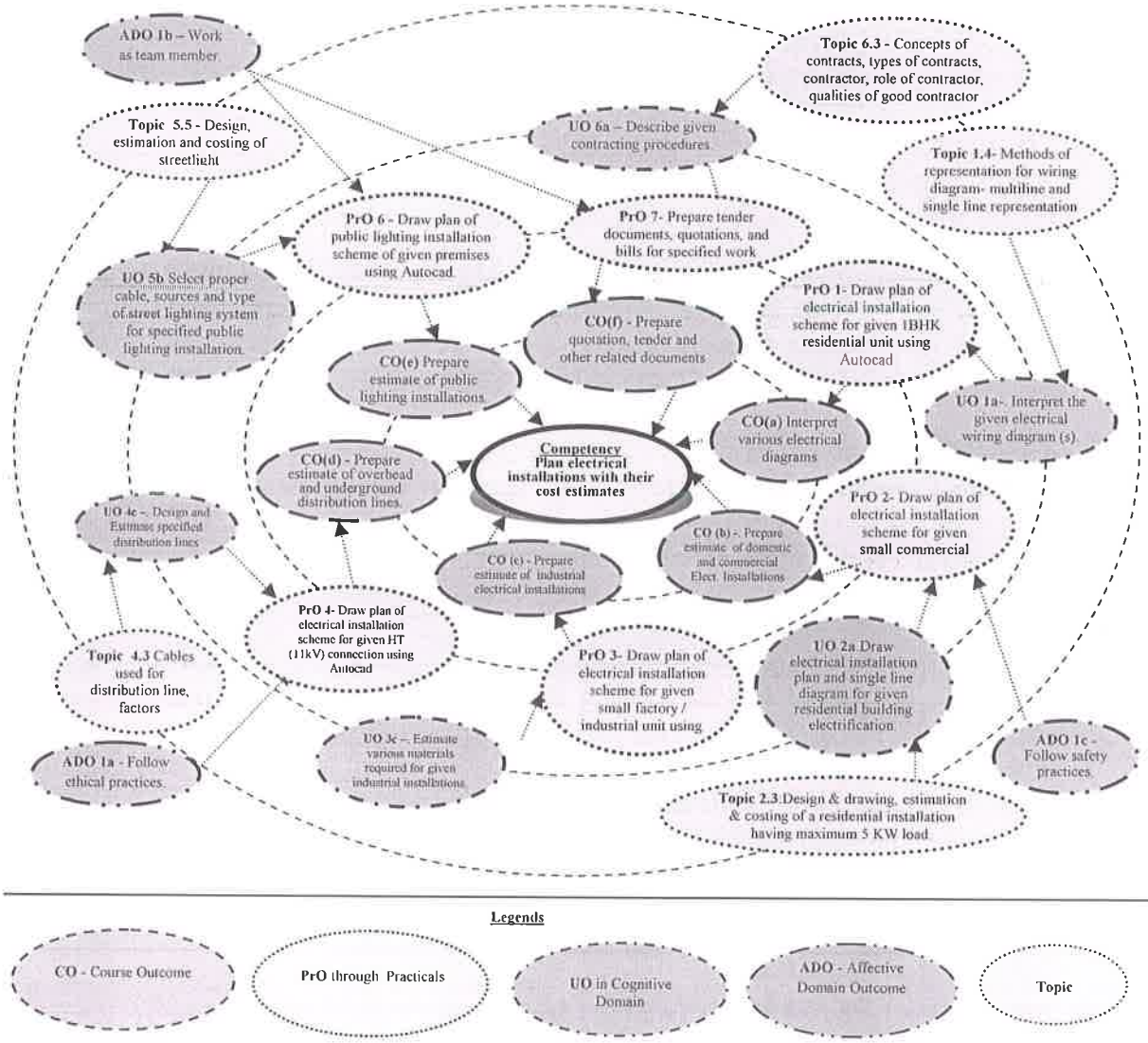

Figure 1 - Course Map

6. SUGGESTED PRACTICALS / EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Draw plan of electrical installation scheme for 1BHK residential unit using Auto-cad and prepare list of materials required.	II	
	1a. Draw the symbols of installation components on the plan showing their location.	II	01#
	1b. Draw the installation wiring route diagram for the plan.	II	01*
	1c. Draw single line wiring diagram of residential installation	II	01#
	1d. Prepare list of materials required.	II	01*

2	Draw plan of electrical installation scheme for small commercial unit using Auto-cad. Also, determine rating of main and sub-distribution board.	II	
	2a. Draw the symbols of installation components on the plan showing their location.	II	01*
	2b. Draw the installation wiring route diagram for the plan	II	01#
	2c. Draw single line wiring diagram of commercial installation.	II	01*
	2d. Determine rating of main and sub distribution board.	II	01*
	# any one * Compulsory		
3	Draw plan of electrical installation scheme for small factory / industrial unit using Auto-cad and type and rating of starter, protective relay.	III	
	3a. Draw the symbols of installation components, starter and motor on the plan showing their location.	III	02*
	3b. Draw the installation wiring route diagram for the plan.	III	01*
	3c. Draw single line wiring diagram of industrial installation.	III	01*
	3d. Determine type and rating of starter, protective relay.		01*
4	Draw plan by using Auto-cad and Estimate the size/ rating of electrical installation system for HT (11kV) scheme.	IV	-
	4a. Draw the symbols of installation components along with equipments (i.e. Transformer, CT, PT and ACB) on the plan showing their location.	IV	02*
	4b. Draw the installation wiring route diagram for the plan.	IV	01*
	4c. Draw single line wiring diagram of HT (11kV) installation.	IV	02*
	4d. Estimate the size/ rating of electrical installation system for HT (11kV) scheme.	IV	02*
5	Draw plan of electrical service installation scheme for LT (415V) line connection using Auto-cad. Prepare the list material required.	IV	
	5a. Draw single line wiring diagram of Overhead service connection.	IV	02*

	5b. List the components required for Overhead service connection.	IV	01*
	5c. Draw single line wiring diagram of Underground service connection.	IV	02#
	5d. List the components required for Underground service connection.	IV	01#
	# any one * Compulsory		
6	Design public lighting installation scheme and Draw plan for the designed lighting scheme using Auto-cad.	V	-
	6a. Draw plan showing location of street lamp post and stay wire.	V	02*
	6b. Draw connection wiring diagram of street lamp post installation.	V	02*
7	Prepare tender documents, quotations, and bills for specified work.	VI	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 %
1	Drawing using AutoCAD	40
2	Understanding line diagram	25
5	Answer to sample questions	25
6	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) Work as a leader/a team member.
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
- 'Organisation Level' in 2nd year
- 'Characterisation 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 administrators.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	NIL	-

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 (in cognitive domain)	Topics and Sub-topics
Unit – I Electrical Wiring Diagram/ (s)	1a. Draw the diagram/(s) of specified electrical installation. 1b. Convert the given wiring diagram into single line diagram. 1c. Explain the specified method of representation of wiring diagram. 1d. Convert the specified single line diagram into the wiring diagram. 1e. Describe the requirements of NEC 2011 related to the given electrical installation.	1.1 Electrical symbols used in electrical diagrams as per Indian standard, multiline and single line representation of conductors. 1.2 Electrical diagrams, their Classification. Definition of wiring and circuit (Schematic) diagram according to IS: 2042(Part-I)-1962. 1.3 Methods of representation for the wiring diagram- multiline and single line representation, conversion of multiline representation into single line and vice versa 1.4 Fundamental principles for electrical installations, Safety in electrical work, permit to electrical work, safety instruction and safety practices 1.5 Scope and features of National Electrical Code 2011 (NEC 2011), Types of electrical installation- Non industrial and industrial, Standard value of voltages and their limits,
Unit – II Domestic and commercial Installations	2a. Draw electrical installation plan and single line diagram for the given residential building electrification. 2b. Draw electrical installation plan and	2.1 Domestic Dwellings/Residential Buildings, its classification, Necessity and reading of Civil Engineering building drawing. Interpretation of electrical installation plan and electrical diagrams. 2.2 General requirements and inspection of electrical installation according to IS: 732-

	single line diagram for the given commercial building electrification. 2c. Estimate materials required for the given domestic and commercial installations. 2d. Estimate materials required for the specified residential service connection.	1982. 2.3 Design and drawing, estimation and costing of a residential installation having maximum 5 KW load. 2.4 Design consideration of electrical installation in commercial buildings. Design electrical installation scheme of commercial complex such as drawing halls, and auditorium. 2.5 Residential building Service Connection- types Underground and overhead. Calculation of Material required for service connection.
Unit- III Industrial Installations	3a. Compare the installations on the given points. 3b. Draw an installation plan, wiring diagrams and single line diagrams for the given industrial installations. 3c. Design the given industrial installation. 3d. Estimate various materials required for the given industrial installations.	3.1 Classification of industrial buildings, Classification based on power consumption, Difference between non-industrial and industrial load, General characteristics of industrial building, selection of wiring system 3.2 Drawing of wiring diagram and single line diagram for single phase and three phase motors. 3.3 Design consideration in industrial installations. 3.4 Design electrical installation scheme and preparation of small industrial unit having total aggregate three -phase load of 30 KW, agricultural pump and flourmill. 3.5 Erection, Inspection and testing of installation as per part 1 section 13 of NEC 2011.
Unit– IV Distribution Lines	4a. Draw the diagram for the given three phase three wire and three phase four wire system by using different types of insulators. 4b. Draw the given pole structures. 4c. Design the specified distribution lines. 4d. Prepare the estimate for the specified distribution lines.	4.1 Introduction to overhead and underground distribution line. 4.2 Materials used for distribution line HT (11KV) and LT (415 V) 4.3 Cables used for distribution line, factors determining selection of LT/ HT power cables, and cable termination methods. 4.4 Design, estimation and costing of HT (11KV), LT (415 V) overhead line and underground cabling.
Unit– V Public Lighting Installation	5a. Draw the installation plan, single line diagram and the other related drawings of specified public lighting installation. 5b. Select the suitable cable, sources and type of street lighting system for specified public lighting	5.1 Classification of outdoor installations, streetlight/ public lighting installation 5.2 Terminology used according to NEC 2011 – Terms related to highway, lighting installation, photometric terms, luminaries etc. Aim of public lighting installation, classification of roads, standard layout of roads. 5.3 Street light pole structures. Selection of equipments, sources used in street light installations. 5.4 Cables, recommended types and sizes of cable.

	installation with justification. 5c. Prepare the list of the given materials required for the given public lighting installations. 5d. Design the specified public lighting installations. 5e. Prepare an estimate for the specified public lighting installation.	On off Control of equipments of street light installation. 5.5 Design, estimation and costing of streetlight.
Unit– VI Contracting	6a. Describe purposes of the given types of estimates and contracts. 6b. Decide the type of estimate for the given work. 6c. Describe the given contracting procedures. 6d. Prepare tender documents, quotations, and bills for the specified work. 6e. Compare tenders and quotations on the given criteria. 6f. Explain the specified actions for e-tendering.	6.1 Purpose of estimating and costing, Qualities of good estimator, essential elements of estimating and costing. 6.2 Meaning and purpose of- Rough estimate, detailed estimate, supplementary estimate, annual maintenance estimate and revised estimate, Factors to be considered while preparation of detailed estimate and economical execution of work. 6.3 Concepts of contracts, types of contracts, contractor, role of contractor, qualities of good contractor 6.4 Type of tender, tender notice, preparation of tender document, and method of opening of tender;e-tendering. 6.5 Quotation, quotation format, comparison between tender and quotation. Comparative statement, format of comparative statement. Order format, placing of purchasing order 6.6 Principles of execution of works, planning, organizing and completion of work, Billing of work.

***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	Electrical Wiring Diagram/ (s)	04	02	00	04	06
II	Domestic and commercial Installations	14	02	08	08	18
III	Industrial Installations	10	02	04	08	14
IV	Distribution Lines	08	02	04	08	14
V	Public Lighting Installations	08	02	02	08	12

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
VI	Contracting	04	02	00	04	06
Total		**48**	**12**	**18**	**40**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare abstract of Indian standards related to industrial and non-industrial installations.
b) Use E- tab for small assignments.
c) Summarize given section of National Electrical Code (NEC), 2011 required for electrical installation.
d) Prepare report on market survey of various electrical accessories, wires and cables (specification, manufacturer, quality, cost)
e) Collect any one electrical drawing of existing electrical installation and prepare estimate for the same.
f) Collect information of tender published in newspaper or of e-tender related to industrial or non-industrial electrical installation and fill necessary documents.
g) Prepare power point presentation for acquiring electrical installation work.

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) Use Flash/Animations to explain various theorems in circuit analysis
f) Guide student(s) in undertaking micro-projects.

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. **Electrical Diagrams**: Prepare a report on existing electrical drawing.
b. **Domestic and commercial Installations**: Collect civil engineering drawing and prepare estimation for the same.
c. **Industrial Installations**: Collect industrial installation plan and prepare estimation for the same using softwares as E-tab etc.
d. **Distribution Lines**: Collect existing installation plan of distribution lines and prepare estimation for the same.
e. **Public Lighting Installations**: Collect existing installation plan of street lighting scheme and prepare estimation for the same.
f. **Contracting:** Collect any tender document related to electrical installation and fill all related documents.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Electrical Wiring Estimating and Costing	Uppal, S.L. C.G. Garg	Khanna Publisher New Delhi, ISBN 9788174092403
2	Electrical Design Estimating and Costing	Raina, K.B. Dr. Bhattacharya, S.K.	New Age International Publisher, First, Reprint 2010, ISBN: 978-81-224-0363-3
3	Electrical Estimating and Costing	Singh,Surjit Ravi Deep Singh,	Dhanpat Rai and Sons, 2014 New Delhi, ISBN:1234567150995
4	Electrical Estimating and Costing	Allagappan, N. S.Ekambarram,	Tata Mc-Graw Hill Publishing Co. Ltd, First Edition, 2000, ISBN:9780074624784
5	A Course in Electrical Installation Estimating and Costing	J.B. Gupta	S.K. Kataria and Sons; New Delhi Reprint Edition, 2013, ISBN: 13: 978-9350142790
6	SP-30:2011, National Electrical Code, 2011	-	Bureau of Indian Standard.
7	IS: 732-1989, Code of Practice for Electrical Wiring Installation	-	Bureau of Indian Standard.
8	Handbook of e-tab		

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) https://ask-the-electrician.com/wiringdiagrams.html

b) https://www.btechguru.com/courses--nptel--electrical-engineering-video-lecture--ee.ht...
c) https://www.electricaltechnology.org/2013/09/electrical-wiring.htm
d) https://www.howstuffworks.com/search.php?terms=electrical%20installatio
e) https://www.electrical4u.com/electrical-engineering-articles/utilities/
f) http://www.neca-neis.org/the-standards
g) http://www.metlabs.com/product-safety/2011-national-electrical-code-nec-updates-standard-for-the-safe-installation-of-electri

Program Name : **Electrical Engineering Program Group**

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

Semester : **Sixth**

Course Title : **Emerging Trends in Electrical Engineering**

Course Code : **22628**

1. RATIONALE

Every technological area is developing at an exponential rate. New applications are coming up and it's mandatory for all technologists to be well versed in these areas to survive and provide satisfactory and quality services to the society in respect of such technologies. This course aims to prepare the diploma graduates to be conversant with such emerging trends for staying in the race. The main areas in which such developments are in, encompasssmart systems, intelligent motor controls, tariff and digitization beyond automation. The course gives a decent introduction of these areas and helps the students to be in a state of preparedness.

2. COMPETENCY

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

- **Use the trending practices in electrical engineering fields.**

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) Suggest the relevant IoT technologies for electrical systems.
b) Suggest the relevant components for implementing a smart grid.
c) Suggest different electrical systems for a smart city.
d) Suggest the relevant MCC or IMCC for the given application/s.
e) Propose the relevant improved tariff and metering for the specified type of consumer.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												Grand Total
				Theory Marks						Practical Marks						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
3	-	-	3	90 Min	70*#	28	30*	00	100	40	-	-	-	-	-	-	100

(#): Online examination of 90 minutes duration.0*
(*): 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 (of MCQ type) to be conducted 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#-External Assessment*

5. COURSE MAP (with sample COs, 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.

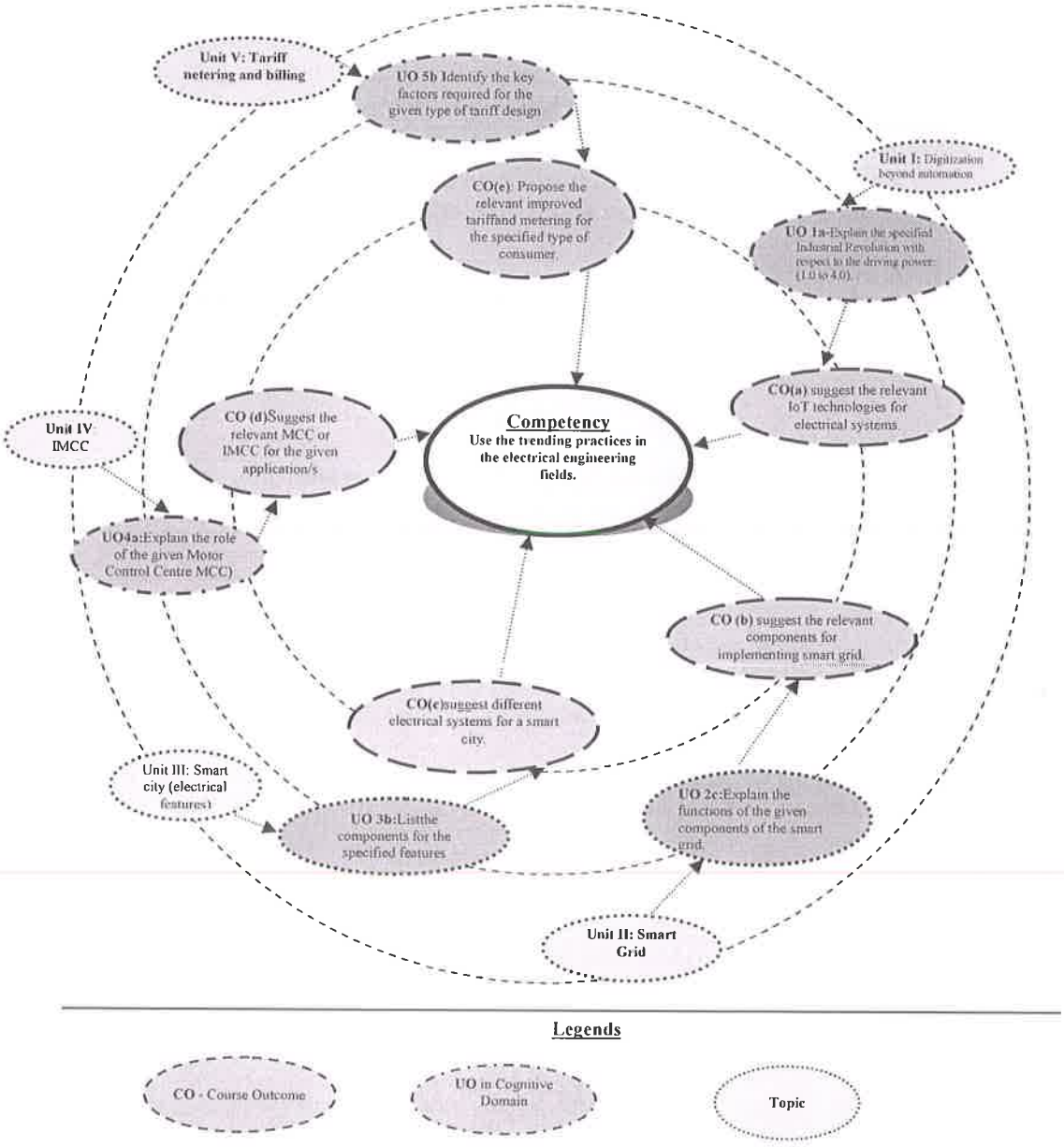

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES: Not Applicable

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED: Not Applicable

8. UNDER-PINNING THEORY COMPONENTS

The following topicsare to betaught 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 Digitization beyond automation	**1a.** Explain the specified Industrial Revolution with respect to the driving power. (1.0 to 4.0). **1b.** Compare the specified Industrial revolutions with reference to the given points. **1c.** Explain the importance of the Industrial Revolution 4.0 with respect to the specified component/s. **1d.** Explain the principle of IoT used in the given application. **1e.** Explain the IoT used in the given electrical application. **1f.** Explain the IoT approach used in the given application for the power distribution system.	**1.1 Industrial Revolutions:** Versions 1.0, 2.0, 3.0 and 4.0; the driving energies/powers for these revolutions. **1.2 Components of Industrial Revolution 4.0**: CPS (Cyber Physical Systems), IoT (Internet of Things), Cloud Computing and Cloud Manufacturing. **1.3 IoT principle and features.** **1.4 IoT application areas in electrical systems**: building automation SCADA, Smart metering, Illumination systems (public lighting). **1.5 IoT initiatives in power distribution systems:** Mobile Apps, Geo coordinates of the network as well as consumer premises, Various digital service platforms for consumers.
Unit- II Smart Grid	**2a.** Explain the need for the given smart grid. **2b.** Draw a labeled layout for the specified smart grid. **2c.** Explain the functions of the given components of the smart grid. **2d.** Identify the barriers for the given smart grid. **2e.** Identify the advantages for the given smart grid. **2f.** List the smart grid projects in the Indian grid. **2g.** Explain the need for the given micro grid.	**2.1 Smart Grid**: Need and evolution, layout and its components,Advantages and barriers, Smart Grid Projects in India. **2.2 Micro-Grid & Distributed Energy Resources**:Needand formation of micro grid, Distributed Generation Systems and Distributed Generation Technologies. **2.3 Smart Substation**:Need, Layout and Components,Typical Specifications of existing substations.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2h. Explain the general layout of the micro grid. **2i.** Explain the working of the given micro grid. **2j.** Explain the significance of the Distributed Generation Systems in the given power scenario. **2k.** Explain the given Distributed Generation Technology. **2l.** Explain the functions of the given components of the smart substation. **2m.** Compare the smart substation and conventional substation for the given criteria.	
Unit– III Smart City (Electrical Features)	**3a.** Explain the relevant features of the specified smart city. **3b.** List the components for the specified features. **3c.** Explain the importance of e-vehicles in the given scenario (environment and energy). **3d.** Explain the working of the given type of e-car. **3e.** Explain with sketch (block schematic) the working of the given type charging station. **3f.** Identify the features of the given fuel cell used in e-cars. **3g.** Identify the barriers for the adoption of e-cars in the specified scenario. **3h.** Identify the components required for the specified features in the given smart home. **3i.** Identify the illumination and its control components /devices for a specified room of a given smart home. **3j.** Explain with schematic sketch the working principle of the given appliance in a	**3.1 Smart City:**Features, components, Objectives and challenges of smart Cities in India. **3.2 E-car:**Role of Electric Vehicles in energy transition, basics of electric car, types of electric cars, working principle, charging stations. Fuel cell for e-cars, types, features, limitations. **3.3 SmartHome:**Features and Components.Illumination and smart appliance control principles (block diagram/s).

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	smart home.	
Unit– IV Intelligent Motor Control Centers	**4a.** Explain the role of the given Motor Control Centre MCC). **4b.** List the devices and components used in (with functions) the given MCC. **4c.** Explain the roles of the components of the given motor control centre (MCC). **4d.** Explain the need for the given type of MCC. **4e.** Explain the roles and functions of the devices /components of the specified IMCC. **4f.** Prepare the outline with components of the IMCC suitable for a given application. **4g.** List the advantages of given type of MCC. **4h.** List the disadvantages of given type of MCC. **4i.** List the advantages of given type of IMCC. **4j.** Suggest an IMCC for a given set of applications.	**4.1 General/traditional (conventional) Motor control center:** Role in Motor protection and motor management. Typical block diagram and general architecture or arrangement. Components: symbols and functions. Traditional MCCs: advantages and disadvantages. **4.2 Intelligent or Smart MCCs:** Need and the requirements that lead to have IMCCs. Role as compared to traditional MCCs. Functional Block diagram/s with general arrangements. **4.3 Devices and Components typical to IMCCs**: Intelligent relays, fuses, control devices, effective security and dedicated software. **4.4 Basic components of intelligent systems**: Control by microprocessor/microcontroller-based systems; networking/technology replaces hard wiring and enhanced diagnostic/protective functionality. **4.5 Selection of MCC**: intelligent and conventional types for typical applications.
Unit– V Tariff, Metering and Billing	**5.a** Describe terms related to tariff economics. **5.b** Identify the key factors required for the given type of tariff design. **5.c** Identify the components for the given type of consumer's electricity bill. **5.d** Compare Average Billing Rate (ABR), Aggregate Revenue Requirement (ARR). **5.e** Explain the suitability of ABT for the given type of	**5.1Tariff:**Power Purchase, Power Purchase Agreements (PPA), Power purchase cost. **5.1.1Tariff Design**:Key factors for Tariff Design, Major Components of an Electricity Bill, various slabs in billing, electricity duty, tax on electricity and Cross subsidy. **5.1.2Special tariffs**: Average Billing Rate (ABR), Aggregate Revenue Requirement (ARR), Availability based Tariff (ABT), Time of Day Tariff (ToD),Recent ToD structure

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	consumer. **5.f** Suggest with justification the applicable type of tariff for the given type of consumer in the present-day scenario. **5.g** Explain the working principal of kVAh meter. **5.h** Determine the electricity bill for the given type of consumer by kVAh billing methodology. **5.i** Differentiate between Net metering and Gross metering. **5.j** List out the relevant MERC rules for Net-metering billing. **5.k** Explain with schematic diagram the use of Net-metering principle for integration of micro-generators with grid system. **5.l** Explain with schematic diagram MRI/AMR reading techniques for the given consumer.	**5.1.3kVAhtariff:**kVAhbilling method for HT and LT Consumers, kVAh Metering methodology, kVAh based Billing calculation, **5.2 Metering and Bill Management:** Working of Net metering and Gross metering, MERC rules for Net-metering bill (Regulations 2015), Application of Net Metering for integration of micro-generators with grid system. Recent Meter Reading techniques-MRI/AMR reading.

***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 QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Digitization Beyond Automation	08	04	02	02	08
II	Smart Grid	08	06	04	02	12
III	Smart City (Electrical Features)	08	08	06	02	16
IV	Intelligent Motor Control Centers	12	04	06	08	18
V	Tariff, Metering and Billing	12	04	08	04	16
	Total	**48**	**26**	**26**	**18**	**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 (one activity by each group), also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Perform general survey regarding the recent electrical technologies.
b. Prepare a power point presentation on IoT applications.
c. Perform Group discussion on new electricity tariff approaches.
d. Prepare a visit report on IMCC.

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.
g. Demonstrate the actions and care to be taken.
h. Arrange a visit to.
i. Arrange expert lecture of industry person.

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 year. In the first two years, the micro-project are group-based. However, in the third year, 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 as applicable. 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 report on existing automation in an industry and suggest improvements.
b. Prepare a reporton Smart Grid.
c. Prepare a report on any four Electrical Applications in Smart cities.
d. Present a power point presentation on various IMCCs.
e. Prepare a report on the procedure of meter reading by MRI and AMR techniques.
f. Conduct a survey and prepare a report on the IMCCs in one industry.
g. Prepare a report on mobile apps used for energy billing procedures.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Fundamentals of Smart Grid Technology	Bharat Modi, AnuPrakash, Yogesh Kumar	S.K. Kataria& Sons; 2015 EditionISBN-10: 9350144859, 13: 978-9350144855
2	Smart Grid: Technology and Applications	JanakaEkanayake, Kithsiri Liyanage et al,	Wiley, 2015 Edition ISBN-10: 9788126557356, 13: 978-8126557356
3	Sustainable Smart Cities in India: Challenges and Future Perspectives	Sharma, Poonam, Rajput, Swati	Springer, ISBN 978-3-319-47145-7
4	Control of Electrical Machines	S K Bhattacharya	New Age International ISBN 8122409970, 9788122409970
5	Handbook of Electrical Motor Control Systems	U. S. Eshwar	Tata McGraw-Hill Education ISBN 0074601113, 9780074601112
6	Applied Intelligent Control of Induction motor Drives	Keli Shi and Tze Fun Chan	Wiley ISBN 10:0470825561, 13:978-0470825563
7	Art of Reading Electricity Bill	Mr. YogendraTalware	Strom EnergiePvt. Ltd. Pune. (stromenergie.pune@gmail.com)

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://www.slideshare.net.in (search with relevant key words)
b. www.youtube.com (search with relevant key words)
c. https://en.m.wikipedia.org/wiki/Technological_revolution#Potential_future_technological_revolutions (general introduction to the new industrial revolution)
d. https://www.plm.automation.siemens.com/global/en/our-story/glossary/industry-4-0/29278 (Industrial revolution 4.0)

e. https://www.industry.siemens.com/topics/global/en/digital-enterprisesuite/Documents/PDF/PLMportal_Industrie-40-Internet-revolutionizes-the-economy.pdf (Industrial revolution 4.0)
f. https://www.trendmicro.com/vinfo/us/security/definition/industrial-internet-of-things-iiot (Internet of things)
g. https://www.leverege.com/blogpost/difference-between-iot-and-iiot
h. https://www.computradetech.com/blog/iot-vs-iiot/
i. https://www.quora.com/Who-coined-the-term-internet-of-things
j. https://iot-analytics.com/the-leading-industry-4-0-companies-2019/
k. http://www.mercindia.org.in/pdf/Order%2058%2042/Order-195%20of%202017-12092018.pdf (MERC order on metering)

Program Name : **Electrical Engineering Program Group**

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

Semester : **Sixth**

Course Title : **Industrial Drives and Control (Elective-II)**

Course Code : **22629**

1. RATIONALE

The electrical engineering applications in many industries use small and large AC and DC motors in some crucial application systems. Further electrical speed control in almost all industrial applications are incomplete without the use of the specific electric drive. This course will empower the students with the necessary skills to identify operate and maintain the AC and DC drives.

2. COMPETENCY

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

- **Maintain different types of electric drives.**

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 the relevant electric drive for the required speed torque characteristics.
b) Maintain the functioning of DC Drives using converters.
c) Maintain the functioning of DC Drives using choppers.
d) Maintain the functioning ofAC Drives.
e) Use microcontroller-based systems for motor control.

4. TEACHING AND EXAMINATION SCHEME

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

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment*

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

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

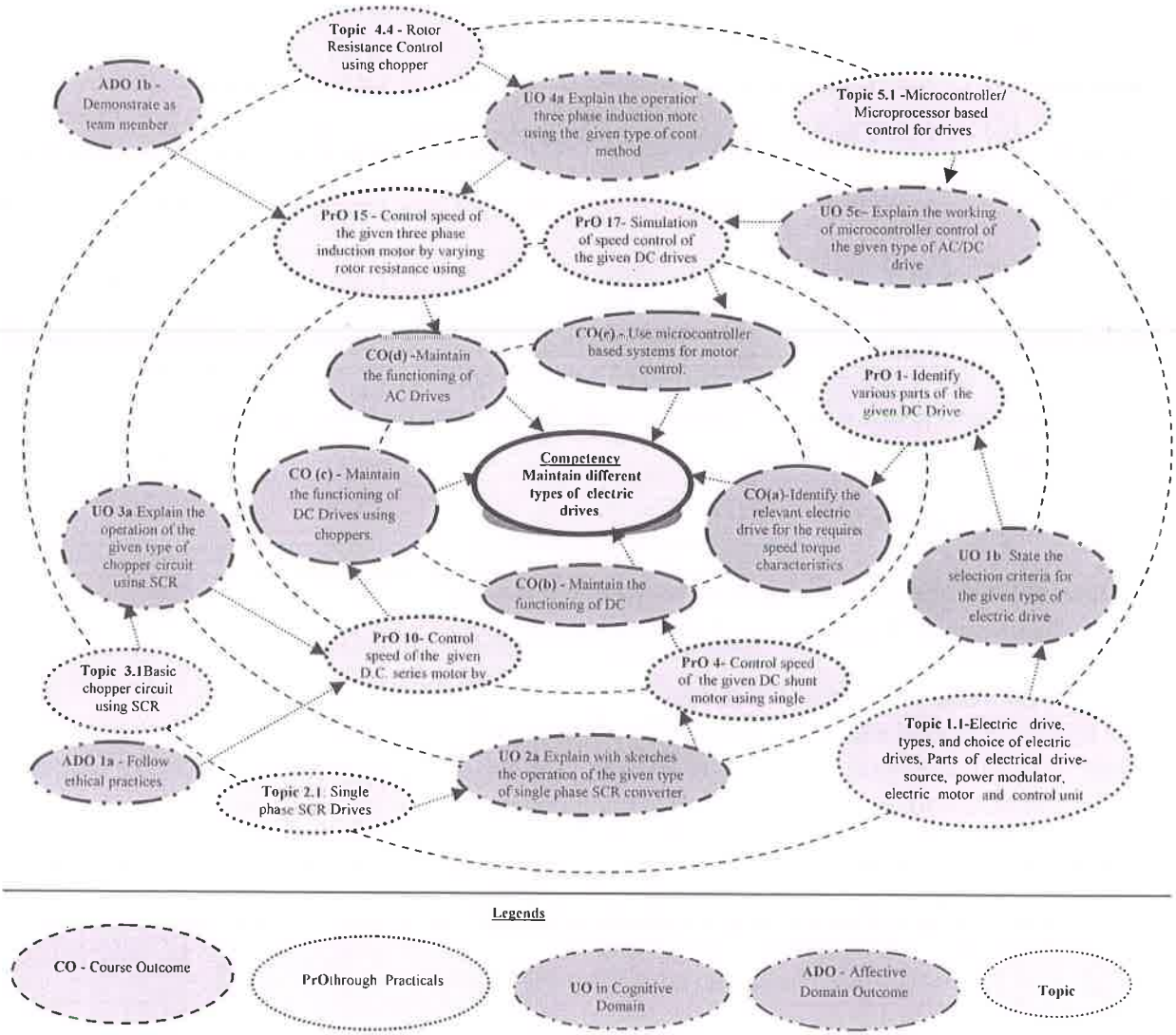

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify various parts of the given DC Drive.	I	02*
2	Identify various parts of the given AC Drive.	I	02*
3	Test the given DC motor to interpret the speed torque characteristics	I	02
4	Control speed of the given DC shunt motor using single phase half wave converter	II	02*
5	Control the speed of the given DC shunt motor using single phase full wave converter	II	02*
6	Control the speed of the given separately excited DC motor by changing the firing angle of SCR using single phase semi converter.	II	02
7	Control speed of the given separately excited DC motor by changing the firing angle of SCR using single phase full converter.	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Check high power SCR/power devices with heat sink arrangement.	II	02*
9	Measure the output voltage of the given chopper for resistive load by varying the frequency and /or duty cycle of chopper.	III	02*
10	Control speed of the given D.C. series motor by varying armature voltage using step down chopper.	III	02*
11	Control the speed of the given D.C. separately excited motor by varying armature voltage using step down chopper.	III	02
12	Control the speed of the given three phase squirrel cage induction motor by varying stator voltage using thyristor circuit.	IV	02
13	Control the speed of the given three phase induction motor by using constant V/f method and plot the graph between speed and frequency.	IV	02*
14	Control the speed of the given three phase induction motor by varying frequency and plot the graph between speed and frequency	IV	02*
15	Control the speed of the given three phase induction motor by sensorless vector control.	IV	02
16	Control the speed of the given three phase induction motor by varying rotor resistance using chopper.	IV	02*
17	Simulation of speed control of the given synchronous motor drives using microcontroller in SCILAB simulation software.	V	02
18	Simulation of speed control of the given DC drives using microcontroller in SCILAB simulation software.	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 and any 04 from remaining 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	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
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) Work as a leader/a team member.
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
- 'Organisation Level' in 2nd year
- 'Characterisation 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 administrators.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Digital storage oscilloscope: Dual trace 50Mhz	3 to 6, 8 to 14
2	Ammeters DC, 0-5/10Amp,0-1.5 Amp,0-2.5Amp,0-0.5/1Amp	3 to 6, 8 to 14
3	Voltmeter DC, 0-150/300V, 0-250/500V,0-75/150V	3 to 14
4	Dimmer: 1-phase,1kVA,230V	1 to 6, 8 to 10
5	Dimmer: 3-phase, 5kVA,440V	11 to 17
6	Resistive load bank upto 10kW	8
7	Digital tachometer 4000 R.P.M.for speed measurement.	3 to 6, 8 to 16
8	DC Series motor 1 to 3 HP	1,9,18
9	DC Shunt motor 1 to 3 HP	1,3,4,18
10	Separately excited DC motor 1 to 3 HP	5,6,10
11	Three phase induction motor 1HPto 3 HP or Fractional horse power motor	12,13,14,15,16
12	Synchronous motor 1 to 3HP	17
13	Simulation soft ware such as SCILAB or similar	17, 18

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught 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 (in cognitive domain)	Topics and Sub-topics
Unit – I Basics of Electric Drives	1a. Describe the block diagram of the given type of electric drive 1b. State the selection criteria for the given type of electric drive 1c. Determine the power rating for the given load curve by equivalent current, torque and power methods. 1d. Select the relevant motor on the basis of given duty cycles with justification. 1e. Describe with sketches the	1.1 Electric drive, types and choice of electric drives, Parts of electrical drive-source, power modulator, electric motor and control unit 1.2 Motor duty class, classification– continuous, short time, intermittent period. 1.3 Motor power rating for continuous, short time and intermittent duty, equivalent torque current, and power methods for fluctuating

	characteristics of the given type of motor(s). 1f. Describe the procedure to maintain the given type of electric motor.	and intermittent loads.(Simple numerical) 1.4 Speed-torque characteristics of DC motors 1.5 Speed-torque characteristics of three phase induction motor
Unit – II DC Drive using converters	2a. Explain with sketches the operation of the given type of single phase SCR converter. 2b. Explain with sketches the operation of the given type of three phase SCR converter. 2c. Give the effect of power factor variation in the given type of SCR motor drive. 2d. Describe the procedure to maintain the given type of DC drive using converter	2.1 Single phase SCR Drives a) Half wave converter b) Full wave converter c) Semi converter d) Dual converter 2.1 Three Phase SCR Drives a) Half wave converter b) Full wave converter c) Semi converter d) Dual converter 2.2 Power factor in SCR motor drives 2.3 Reversible SCR Drives.
Unit- III DC Drive using choppers.	3a. Explain with sketches the operation of the given type of chopper circuit using SCR. 3b. Explain with sketches the operation of the given type of single quadrant chopper drive with quadrant diagram 3c. Explain with sketches the operation of the given type of two quadrant chopper drive with quadrant diagram 3d. Explain with sketches the operation of chopper controlled DC Drive in Solar and battery powered vehicles 3e. Describe the procedure to maintain the given type of DC drive using chopper	3.1 Basic chopper circuit using SCR 3.2 Classification based on output voltage and quadrant of operation 3.3 Chopper Controlled DC Drives a) Class A Chopper Drive b) Class B Chopper Drive c) Class C Chopper Drive d) Class D Chopper Drive e) Class E Chopper Drive 3.3 Application of chopper control drive in Solar and battery powered vehicles.
Unit– IV AC Drives	4a. Explain with sketches the operation of three phase induction motor using the given type of control method 4b. Explain with sketches the operation of three phase induction motor using the given type ofslip power recovery system 4c. Describe with sketches the working of the given type of solar powered pump drives. 4d. Describe the procedure to maintain the giventype of AC	4.1 Stator voltage control method using thyristor circuit. 4.2 Variable frequency control method using square wave inverter 4.3 Constant V/F control method 4.4 Rotor resistance control using chopper 4.5 Slip power recovery system 4.6 Solar powered pump drives 4.7 Drives required at each stage for following applications: Textile mills, Steel rolling mills, Paper mills, Sugar mills

	drive.	
Unit-V Advanced techniques of motor control	5a. Explain with sketches the working of PLL control for the given type of DC motor 5b. Explain with sketches the working of microprocessor control of the given type of AC/DC drive 5c. Explain with sketches the working of microcontroller control of the given type of electricdrive. 5d. Describe the procedure to maintain the given type of electric drive using microcontroller.	5.1 Microcontroller/ Microprocessor based control for drives. 5.2 Phase locked loop control of DC motor. 5.3 AC/DC drive using microprocessor control 5.4 AC/DC drive using microcontroller control. 5.5 Synchronous motor drives. 5.6 Ratings and specifications of stepper motor. 5.7 Stepper motor drives employing microcontroller (No programming)

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 QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Electric Drives	4	2	4	4	10
II	DC Drive using converters	12	4	4	8	16
III	DC Drive using choppers	12	4	4	8	16
IV	AC Drives	12	4	4	8	16
V	Advanced techniques of Motor Control	8	--	4	8	12
Total		**48**	**14**	**20**	**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) Visit any one textile mill to know the types of drives used in each stage of operation.
b) Visit any one sugar mill to know the types of drives used in each stage of operation.
c) Visit any one paper mill to know the types of drives used in each stage of operation
d) Read the safety precautions of various electric motors used in different drives
e) Find troubleshooting techniques and steps to troubleshoot DC drives

f) Make comparative table for various drives based on its application and maximum power ratings.
g) Check the performance of at least two different types of drives using simulation software like Scilab.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment ofthe 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) Use Flash/Animations to explain various theorems in circuit analysis
f) Guide student(s) in undertaking micro-projects.

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 six.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

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

a) **AC motor power rating for given application**: Determine the power rating of fractional h.p. ac motor requiredfor the given desert cooler to lift the water up to 1.5 meter. Assume efficiency between 50 to 75% of rated load.
b) **Brush less DC motor**: Design and assemble 24 Volt, 500 W BLDC motor for robotic applications.
c) **Reversible SCR drive** : Design reversible SCR drive using four quadrant chopper or using L293D and L298 dual H-bridge motor driver ICs for controlling the rotation of the motor in both clockwise and anticlockwise direction.
[Rcf.- http://playwithrobots.com/dc-motor-driver circuits/]
d) **PWM inverter**: Design PWM inverter using 8051 micro controller for speed control of the given AC motor.
e) **Battery operated vehicles**: Design a battery operated bicycle of rating 24V/36V/48V, 250W/500/W/1000W using brushless DC motor.A battery electric vehicle (BEV) is a type of electric vehicle (EV) that uses chemical energy stored in rechargeable battery packs. BEVs use electric motors and motor controllers instead of internal combustion engines (ICEs) for propulsion. They derive all power from battery packs

and thus have no internal combustion engine, fuel cell, or fuel tank. BEVs include motorcycles, bicycles, scooters, skateboards, rail cars, watercraft, forklifts, buses, trucks and cars.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Fundamentals of Electrical Engineering	Saxena, S.B lal; Dasgupta, K.	Cambridge university press pvt. Ltd., New Delhi, 2016, ISBN: 9781107464353
2	A Text Book of Electrical Technology Vol-II	Theraja, B. L.; Theraja, A. K.	S. Chand and Co. Ramnagar, New Delhi, 2012; ISBN :9788121924405
3	Basic Electrical Engineering	Mittle, V.N. ; Mittle, Arvind	McGraw Hill Education, Noida, 2005ISBN: 978-00-705-9357-2
4	Power Electronics	P.C.Sen	Mcgraw-Hill Publishing CompanyLimited, New Delhi.
5	Fundamentals of Electrical Drives,	Dubey,Gopal K.	Narosa Publishing House,New Delhi, 2016, Second Edition
6	Electrical Drives Concepts and Applications	Subrahmanyam, Vedam	Mcgraw-Hill Publishing New Delhi, 2016
7	Power Electronic Systems Theory and Design	Agrawal,Jai P.	Pearson Education ,Inc. New Delhi, 2016
8	Electrical Machines	Deshpande,M.V.	PHI Learning, New Delhi, 2016
9	A first course on Electrical Drives	Pillai,S.K.	Wiley Eastern Ltd. New Delhi, 2016 ISBN 81-224-0166-X

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/AC-DC DRIVES
e) www.dreamtechpress.com /ebooks/AC-DC DRIVES
f) www.nptelvideos.in/electrical engineering/ AC-DC DRIVES
g) www.learnerstv.com/free-engineering/AC-DC DRIVES
h) www.orcad.com/resources/orcad-downloads
i) www.electricaltechnology.org
j) www.electrical4u.com

Program Name : **Electrical Engineering Program Group**

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

Semester : **Sixth**

Course Title : **Power System Operation and Control (Elective-II)**

Course Code : **22632**

1. RATIONALE

The diploma engineers working in power sector, while undertaking major activities related to transmission and distribution systems they should be able to interpret significance of the activities assigned to them. For example, they should be aware of active and reactive power control strategies/mechanisms, and methods to ensure power system stability. They should also be aware of load flow studies and load dispatch. Hence, this course is designed to develop awareness about these concepts in diploma pass outs so that they may ensure power system stability. Thus this course is important for diploma electrical engineers who wish to work in power generation, transmission and distribution companies.

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 power system network for stability and load dispatch.**

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) Interpret real and reactive power flow in power system network.
b) Interpret the functioning of Automatic Generation control.
c) Interpret development of Load flow studies.
d) Apply different techniques to maintain stability of power system.
e) Interpret factors involved in Load dispatch.

4. TEACHING AND EXAMINATION SCHEME

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

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

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

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

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

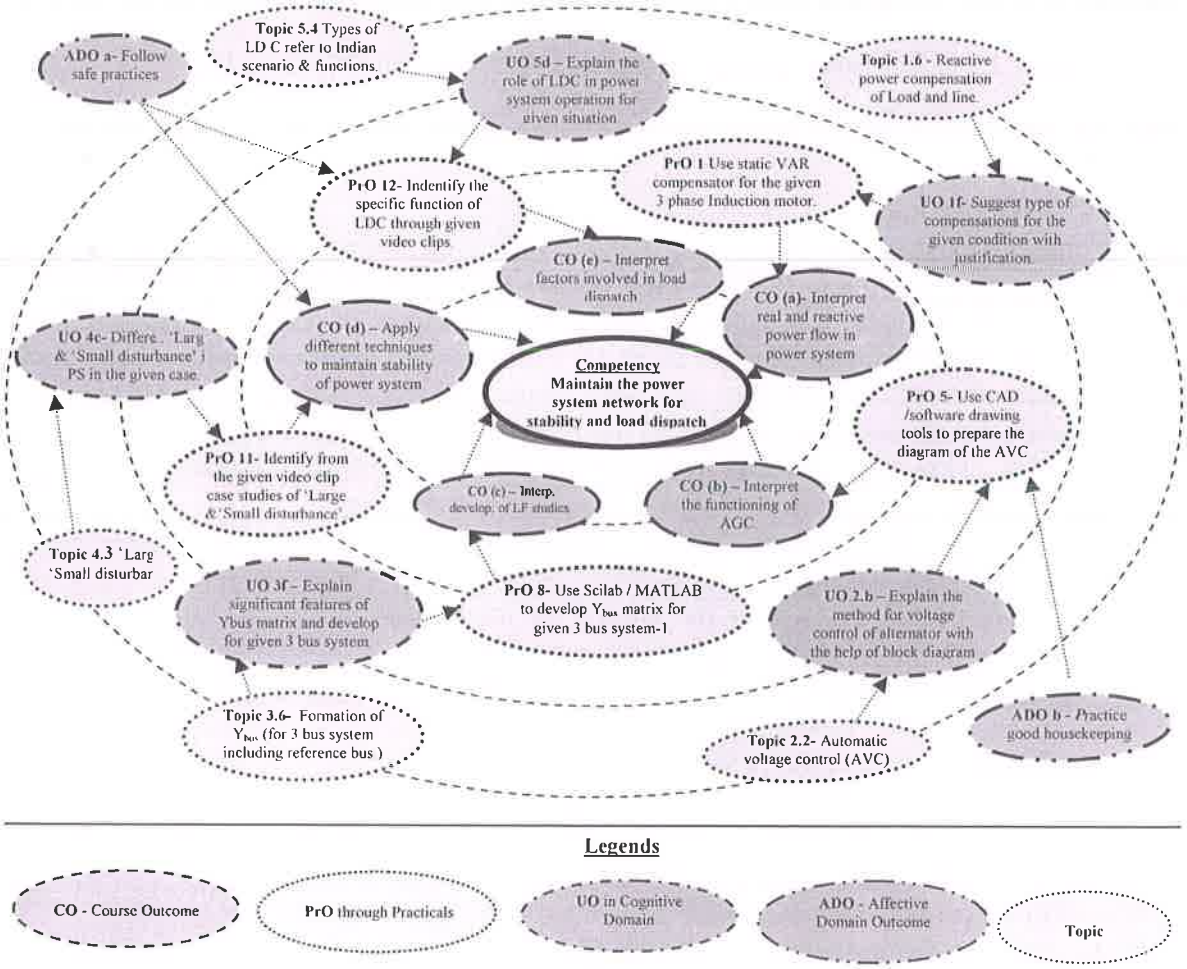

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use static VAR compensator for the given three phase Induction motor.	I	02*
2	Identify the different voltage controls of H.V. substation with respect to the given video clip with justifications.	I	02
3	Identify the different frequency controls of a power plant with respect to the given video clip with justifications.	I	02
4	Identify different components of Turbo generator control with respect to the given video clip/ animation/chart with justifications.	II	02
5	Use CAD /software drawing tools to prepare the schematic diagram of the Automatic Voltage Control (AVC) for the given condition.	II	02£
6	Use CAD /software drawing tools to prepare the schematic diagram of the Automatic Load Frequency Control (ALFC) for the given condition.	II	02£

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Use CAD /software drawing tools to prepare the schematic diagram of the Automatic Generation Control (AGC) for the given condition.	II	02£
8	Use Scilab / MATLAB to develop Y_{bus} matrix for given 3- bus system-1.	III	02#
9	Use Scilab / MATLAB to develop Y_{bus} matrix for given 3- bus system-2.	III	02#
10	During the maintenance outages, determine the effect on SLFE for given power system using relevant software.	III	02*
11	Identify from the given video clip case studies of 'Large disturbance' and 'Small disturbance'.	IV	02*
12	Identify the specific function of Load dispatch center through given video clips.	V	02*
13	Identify specific reasons for Load shedding adopted by DISCOM in specific area from given video clip (case-1).	V	02$
14	Identify specific reasons for Load shedding adopted by DISCOM in specific area from given video clip (case-2).	V	02$
	Total		**28**

Legend: £- Minimum two ; # -Minimum one; $- Minimum one

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 10 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	Preparation	20
2	Setting and operation	20
3	Safety measures	10
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) Work as a leader/a team member.
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
- 'Organisation Level' in 2nd year
- 'Characterisation 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	Induction motor (3phase /1 phase,3kW)	1
2	Ammeters MI Type: AC/ DC 0-5-10Amp (3 in number)	1
3	Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V(1 in number)	1
4	Wattmeter: Single phase, single element 2.5/5Amp, 200/400V, (2 in number)	1
5	Dimmer: 3-phase, 5kVA	1
6	Star- delta starter :3phase,3kW	1
7	Load bank: Inductive bank, 3-phase, 5kW, 415V	1
8	Capacitor bank, 3-phase, 5kW, 415V	1
9	Knife switch :10Amp	1
10	Chart relevant to practical	4
11	Electrical –CAD or equivalent software	5,6
12	Software –Scilab / MATLAB or other open sources.	7,8,9
13	Internet facility	2 to 13
14	Videos relevant to different practical	2,3,4,10, 11,12,13

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 Real And Reactive Power Flow	1a. Interpret the impact of real and reactive power imbalance for the given data. 1b. Explain the adverse effect of real power imbalance in the given situation for the power system. 1c. Explain the effect of the given condition of the frequency on the specified side in the power system. 1d. Explain the causes for imbalance of reactive power flow in the given situation for the power system. 1e. Explain the effect of the given condition of the voltage on the specified side in the power system 1f. Suggest type of compensations for	1.1 Concept of power flow and real power balance and reactive power balance and its adverse impact. 1.2 Relation between Real power balance and frequency of the system (derivation) 1.3 Need of constant frequency control, adverse impact of variation in frequency on consumers and supply agencies. 1.4 Relation between reactive power balance and voltage of the system (derivation) 1.5 Effect of change in voltage on consumers and supply agencies. 1.6 Reactive power compensation for

	the reactive power under given condition with justification.	Load and line.
Unit– II Automatic Generation Control	2a. Explain the specified method used for speed control of the given turbo-generator using schematic diagram. 2b. Explain the specified method for voltage control of given alternator using block diagram. 2c. Explain with sketches the application of Load-frequency control for the given type of control area. 2d. Describe the functioning of the Automatic Load Frequency Control using the block diagram for the given type of generator. 2e. Draw the block diagram of Automatic Generation Control (AGC) for the specified generating system.	2.1 Schematic diagram of Turbo generator speed control (Turbine speed governing system) and its functioning. 2.2 Automatic voltage control (AVC) 2.3 Load frequency control (single area case) 2.4 Schematic diagram of The Automatic Load Frequency Control (ALFC) and its functioning. 2.5 Schematic diagram of The Automatic Generation Control (AGC) and its functioning.
Unit-III Load flow studies	3a. Identify the significance of Load flow analysis for the given power system. 3b. Categorize the data required for Load flow studies for the given power system. 3c. Develop the Static Load Flow Equation (SLFE) for a simple two bus system. 3d. Interpret the Characteristics' of the given SLFE for specified power system.. 3e. Identify the information obtained from the given Load flow study. 3f. Identify significant features of the given Y_{bus} matrix and develop for given 3 bus system.	3.1 Concept of Load flow studies and its need. 3.2 Data required for Load flow studies. 3.3 Static load flow equation (SLFE) for simple two bus system and definition of parameters (only equation). 3.4 Characteristics' of SLFE. 3.5 Information obtained from Load Flow Studies 3.6 Formation of Y_{bus} (for 3 bus system including reference bus).
Unit –IV Power system stability	4a. Explain the specified type of Stability of given power system. 4b. Explain the adverse effects of instability of given power system on consumers and on power utility companies. 4c. Differentiate 'Large disturbance' and 'Small disturbance' in the given power system in specified case. 4d. Identify the type of power system stability condition for the given	4.1 Illustration of terms: Power system stability, overall stability, Stability limit and Instability. 4.2 Adverse effects of instability of power system. 4.3 'Large disturbance' and 'Small disturbance' 4.4 Classification of Stability: i) Steady state stability ii) Transient state stability iii) Dynamic stability 4.5 Stability studies with the help of

	power system. 4e. Explain the different stability condition of the given power system with the help of power angle diagram. 4f. Describe the specified method of improving Steady state stability condition of the given power system. 4g. Explain specified method of improving Transient State Stability condition for the given power system.	power angle diagram (Steady state stability and Transient state stability 4.6 Methods of improving Steady state stability condition. 4.7 Methods of improving Transient State Stability condition (Conventional and New techniques).
Unit-V Load dispatch	5a. Explain the idea of Load dispatch in the given power system. 5b. Explain impact of specified factors on the Load forecasting of the given power system. 5c. Explain impact of the specified factors on Load shedding in power system operation. 5d. Explain the role of Load Dispatch Center in power system operation for the given situation.	5.1 Concept of Load dispatch. 5.2 Load forecasting i) Significance of forecasting. ii) Use of load curve. iii) Environmental and social factors in load forecasting. 5.3 Load shedding and its governing factors 5.4 Types of Load Dispatch Centre refer to Indian scenario and their functions.

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	Real And Reactive Power Flow	10	02	04	04	10
II	Automatic Generation Control	08	04	08	00	12
III	Load flow studies	10	02	08	08	18
IV	Power system stability	12	04	04	08	16
V	Load dispatch	08	04	06	04	14
Total		48	**16**	**30**	**24**	**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 any two of the 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 the information about impact of variation in frequency –case study.
b) Collect the information about impact of variation in voltage –case study.
c) Create awareness of Load shedding and its importance among students.
d) Carry out internet survey to collect information related LDCs and their locations with Indian scenario.
e) Write report on power failure in nearby area.
f) Prepare case study on recent Major power failure in India / world.
g) Prepare a report on impact of Wind/Solar farms on Power system operation.

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 Flash/Animations to explain working of Real power balance and its relation with frequency.
g) Use Flash/Animations to explain working stability of power system.
h) Pre-guided visits to Load dispatch / HV substations centers in which the students will observe functioning of LDC.

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 is 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 she/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) **Indian National grid and Regional grid:** Collect information and prepare charts with significant details.
b) **Major power failure:** Collect information about power failure in / outside India.
c) **Load dispatch center**: Prepare technical presentation on details of functioning of RLDCs.

d) **Social impact on Load forecasting**: Collect information about nearby social activities which affect Load forecasting.
e) **Environmental impact on Load forecasting**: Collect information about changes in environment which affect Load forecasting.
f) **Load shedding:** Collect information about strategy adopted in specific area.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Modern Power System Analysis	Nagrath, I. J. Kothari, D. P.	McGraw Hill Education, New Delhi 2003 ISBN-0-07-049489-4
2	Electric Power Systems (Analysis ,Stability and Protection)	Gangadhar, K. A.	Khanna Publishers, Delhi. India, 2006. ISBN 9788174090041
3	Elements of Power System; Analysis e-book	Stevenson, William	McGraw-Hill Book Company, New York, 2014 (4th addition) ISBN: 9780070612785
4	Power System Analysis, operation and control	Chakrabarty, Abh ijit	PHI Learning, New Delhi, New Delhi, 2010 ISBN: 788120340152
5	Electrical Power System	Wadhava, C. L.	New Academic Science, UK, 2017 ISBN: 9781781831014
6	An introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems –	Chakrabarti, D P A Kothari, A K Mukhopadhyay, Abhinandan De	PHI Learning, New Delhi, 2015 ISBN: 9788120340503
7	Power Generation Operation and Control	A. J. Wood, B. F. Woolenberg,	John Wiley and Sons, UK ISBN:978-0-471-79055-6

14. SOFTWARE/LEARNING WEBSITES

a) https://mahatransco.in/information/details/load_despatch
b) ieee.org/houston/files/2018/04/Fundamentals-oF-Turbine-Generator-Speed-Control.pdf
c) https://www.electrical4u.com/power-system-stability/
d) https://mahatransco.in/information/details/load_despatch
e) http://nptel.ac.in/courses/108101040/
f) http://www.electrical-engineering-portal.com/
g) http://nptel.iitm.ac.in/courses.php
h) https://www.youtube.com/watch?v=ouWOhk1INjo

Program Name : **Electrical Engineering Program Group**

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

Semester : **Sixth**

Course Title : **Electrical Substation Practices (Elective-II)**

Course Code : **22633**

1. RATIONALE

The electrical power for many industries is made available through their own substations. This course will empower the students with the necessary knowledge of operations and maintenance of substation equipment. This course will also be useful for students to observe the safety while working in substations as well as to improve the quality of power system. In this course new type of substation like Gas Insulated substation is also included.

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 safe working of different types of electrical substations.**

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 safety rules for Substation.
b) Maintain substation earthing and neutral grounding.
c) Maintain the Sub-station Equipment and Bus bar layout
d) Interpret single line diagram of substation.
e) Maintain Gas insulated Substation

4. TEACHING AND EXAMINATION SCHEME

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

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **ESE** -End Semester Examination; **PA** - Progressive Assessment*

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

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

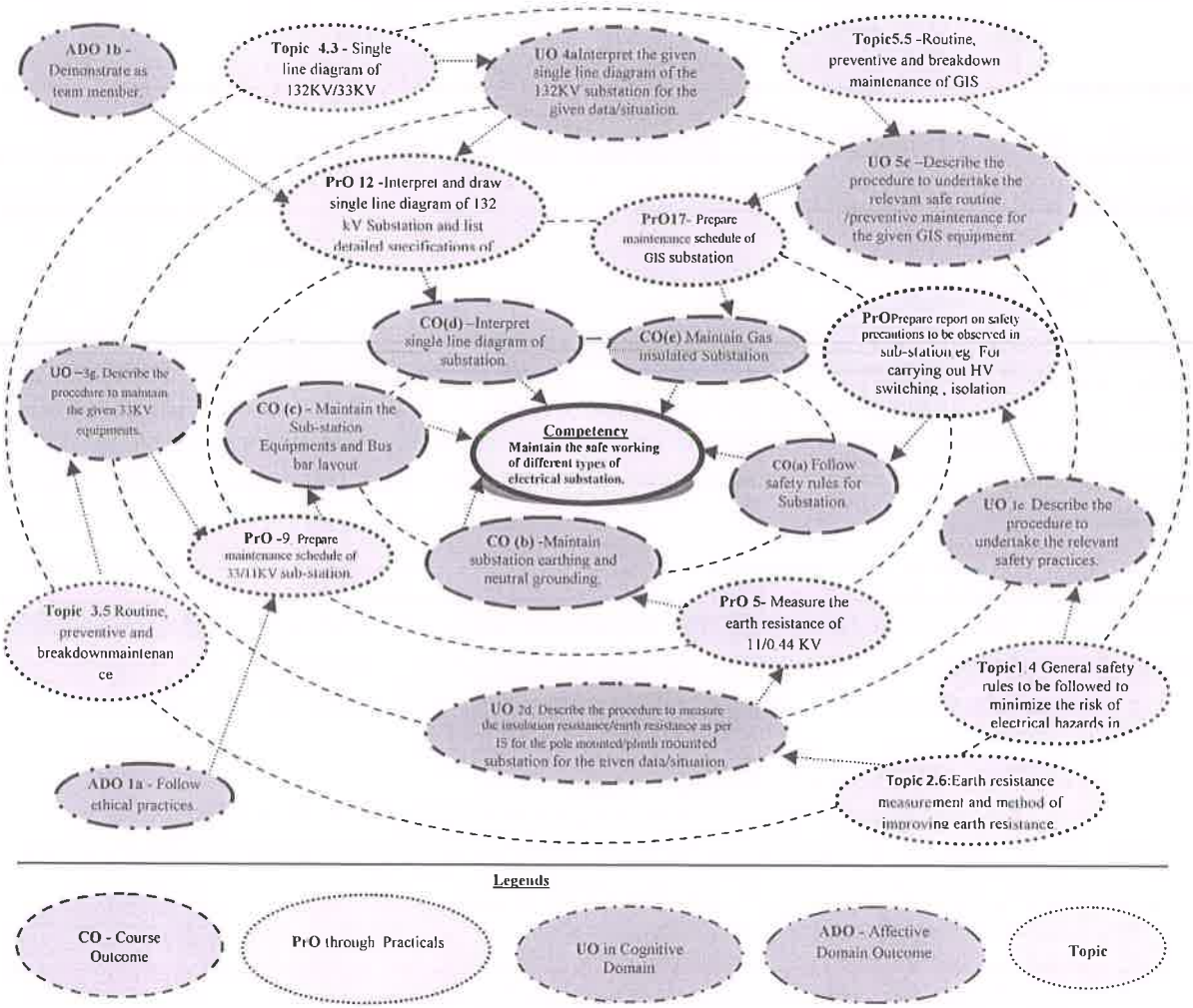

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Prepare report on safety precautions to be observed in sub-station.eg. For carrying out HV switching , isolation from other feeding points etc.	I to V	02*
2	Draw layout and prepare report of 11 KV pole mounted substation earthing after seeing the relevant video clip.	II	02*
3	Draw layout and prepare report of 11 KV plinth mounted substation earthing.	II	02
4	Interpret and draw single line diagram of 11 kV Substation and list detailed specifications of equipment used.	II	02
5	Measure the earth resistance of 11/0.44 KV substation. Compare with standard values and prepare report for improvement of earth resistance.	II	04*
6	Prepare Visit report of 33/11KV sub-station and draw the layout diagram.	III	04*
7	Interpret and draw single line diagram of 33 kV Substation and list detailed specifications of equipment used.	III	04

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Measure the earth resistance and insulation resistance of 33/11KV substation	III	04
9	Prepare maintenance schedule of 33/11KV sub-station.	III	02*
10	Perform BDV (break down voltage) test on power transformer oil	III	04
11	Perform specific gravity test and measure battery voltage and prepare maintenance schedule of Battery	III,IV	02
12	Interpret and drawsingle line diagram of 132 kV Substation and list detailed specifications of equipment used.	IV	04*
13	Locate and record the hot spot(s) in substation equipment, terminals, conductor joints by using non contact type thermal sensor.	IV	04
14	Prepare a report on maintenance of SF6 circuit breakers in sub station	IV	02
15	Use the given firefighting equipment used in 11KV, 33KV and 132KV substation.	IV	02*
16	Interpret and draw single line diagram of 33 KV Gas Insulated sub-station.	V	02*
17	Prepare maintenance schedule of GIS substation.	V	02
	Total		**48**

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 and any 04 from remaining, 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	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
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 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) Work as a leader/a team member.
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
- 'Organisation Level' in 2nd year
- Characterisation 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 administrators.

S. No.	Equipment Name with Broad Specifications	PrO.No.
1	Multimeter, clip on meter , voltmeters, ammeters	1 to 17
2	Digital Earth tester	05 , 08
3	Motorized megger (1000 V)	8
4	Hygrometer	11
5	Non contact type thermometer / thermal sensor for locating hot spots	13
6	Oil testing kit (0-60) kv	10

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught 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 (in cognitive domain)	Topics and Sub-topics
Unit – I Overview of Sub-stations.	1a. Select the site for the substation for the given data/situation with justification. 1b. Classify the substation based on the given data/situation. 1c. Interpret of symbols used in the given single line diagram. 1d. Describe the procedure to maintain the earth resistance as per IE rules for the given data/situation. 1e. Describe the procedure to undertake the relevant safety practices in substation for the given data/situation.	1.1 Need of electrical substation. Factors governing the selection of the site of the substation, Classification of sub-station based on voltage level, Indoor and Outdoor, configuration, application, various symbols used in single line diagram. 1.2 Conductor used in main bus and auxiliary bus for 11KV, 33KV, 132KV substation. 1.3 Typical earth resistance values of various substation and structures as per IE rules:- 11KV,33KV,132KV substation and double pole structure, transmission tower(tower foot resistance) 1.4 General safety rules to be followed to minimize the risk of electrical hazards in substation.
Unit – II 11KV substation	2a. Draw the layout diagram for the pole mounted/plinth mounted substation for the given	2.1 Need for pole mounted and plinth mounted substation. 2.2 11KV/440V Pole mounted

	data/situation. 2b. Interpret the given single line diagram of the pole mounted/plinth mounted substation for the given data/situation. 2c. Select the relevant equipment and accessories required for the 11KV pole mounted substation for the givendata/situation with justification. 2d. Describe the procedure to measure the insulation resistance/earth resistance as per IS for the pole mounted/plinth mounted substation for the given data/situation. 2e. Describe the procedure to undertake the relevant safe routine /preventive maintenance for the specified11KV substation equipment. 2f. Describe the procedure to maintain the given 11KV equipment.	substation Equipment and accessories: Functions and rating of: Three phase distribution transformer, Lightning arrester(LA), Metering Current transformer (CT), Metering voltage transformer PT, Air break switch (AB switch),Drop out (DO) fuse, insulators and Distribution box. 2.3 Layout and Single line diagram of pole mounted substation. 2.4 Insulation resistance measurement. 2.5 Earthing: Equipment earthing and System earthing. 2.6 Earth resistance measurement and method of improving earth resistance. 2.7 Routine, preventive and breakdown maintenance. 2.8 Safety practices followed during routine, preventive and breakdown maintenance.
Unit – III 33KV substation	3a. Draw the layout diagram for the 33KV substation for the given data/situation. 3b. Interpret the given single line diagram of the 33KV substation for the given data/situation. 3c. Select the relevant equipment and accessories required for the 33KV substation for the given data/situation with justification. 3d. Describe the procedure to undertake the relevant safe routine /preventive maintenance for the given 33KV substation equipment. 3e. Describe the procedure to undertake the measurement of BDV of the transformer oil for the given data/situation. 3f. Describe the procedure to use therelevant fire-fighting equipment for the given situation. 3g. Describe the procedure to maintain the given 33KV equipment.	3.1 Need of 33KV/11KVsubstation. 3.2 33KV/11KVsubstation Equipment and accessories: Functions and rating of:Power transformer, Lightning arrester(LA), Instrument Transformer-Current transformer (CT) and Potential transformer (PT), HT fuses, Isolating switches (Isolator), Insulators, control and relay panel, station transformer, capacitor bank, battery and charger and circuit breaker. 3.3 Layout and Single line diagram of 33KV substation. 3.4 Earthing: Equipment earthing and System earthing 3.5 Routine, preventive and breakdown maintenance. 3.6 BDV (break down voltage) test on power transformer oil. 3.7 Safety practices followed during routine, preventive and breakdown maintenance. 3.8 Fire-fighting equipment for the different situations in the substation.
Unit – IV 132 KV	4a. Interpret the given single line diagram of the 132KV substation	4.1 Need of 132KV/33KVsubstation. 4.2 132KV/33KVsubstation

substation	for the given data/situation. 4b. Select the relevant equipment and accessories required for the 132KV/33KV substation for the given data/situation with justification. 4c. Describe the procedure to undertake the relevant safe routine /preventive maintenance for the given 132KV substation equipment. 4d. Describe the procedure to use the relevant fire-fighting equipment for the given situation. 4e. Describe the procedure to maintain the given component(s) of the 132KV substation. 4f. Describe the procedure to locate and record the hot spot(s) in 132KV substation.	Equipment and accessories: Functions and rating of: Power transformer, Lightning arrester (LA), Instrument Transformer-Current transformer (CT) and Potential transformer (PT), Capacitor voltage transformer (CVT),HT fuses, Isolating switches (Isolator), Insulators, control and relay panel, station transformer, capacitor bank, battery and charger, wave trap/wave drum, Power line carrier communication (PLCC) and circuit breaker. 4.3 Single line diagram of 132KV/33KV substation. 4.4 Earthing: Equipment earthing and System earthing. 4.5 Step potential, touch potential, mesh potential, transferred potential, earth mat or grid. 4.6 Routine, preventive and breakdown maintenance; Safety practices followed during routine, preventive and breakdown maintenance. 4.7 Fire-fighting equipment for the different situations in the substation. 4.8 Non-contact type thermal sensor to locate and record hot spot(s) in a substation.
Unit– V Gas Insulated sub-station	5a. Interpret the single line diagram of the GIS for the given data/situation. 5b. Describe the function of the given part(s) of the GIS. 5c. Describe the procedure to undertake the relevant safe routine /preventive maintenance for the given GIS equipment. 5d. Describe the procedure to use the relevant fire-fighting equipment for the given situation. 5e. Describe the procedure to maintain the given GIS equipment.	5.1 Need of gas insulated substation (GIS). 5.2 Essential parts of GIS, advantages of GIS, drawbacks of GIS. 5.3 Single line diagrams of GIS. 5.4 Partial discharge monitoring. 5.5 Routine, preventive and breakdown maintenance of GIS. 5.6 Safety practices followed during routine, preventive and breakdown maintenance. 5.7 Firefighting equipment used in GIS.

***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 QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Overview of Sub-stations	06	00	04	02	06
II	11 KV substation	12	04	04	10	18
III	33 KV substation	12	02	04	12	18
IV	132 KV substation	10	04	04	08	16
V	Gas Insulated sub-station	08	02	04	06	12
Total		**48**	**12**	**20**	**38**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare report on market survey of various three phase power and distribution transformers(specification, manufacturer, application, cost)
b) Prepare model of pole mounted distribution transformer.
c) Prepare power point presentation related to substation equipment.
d) Prepare power point presentation related to maintenance of substation.
e) Prepare a single line diagram of substation.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment ofthe 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) Use Flash/Animations to explain various theorems in circuit analysis
f) Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so

that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

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

a) **Power / distribution transformer**:Prepare chart showing three phase power / distribution transformer.
b) **Neutral grounding**: Collect specification from different manufacturers and prepare report.
c) **Sub-station equipment:** Collect specification from different manufacturers and prepare report.
d) **Gas Insulated Substation:** Collect photographs with details of Gas Insulated Substationand identify different parts (specification, application, cost, features, manufacturer)
e) **Single line diagram of sub-station:** Prepare Single line diagram of sub-station

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Generation Of Electrical Energy	Gupta, B.R.	Eurasia Publishing House (Pvt.) Ltd, , 1996. ISBN :81-219-0102-2
2	Principles Of Power System	Mehta,V.K.	S.Chand&Co.Ltd, New Delhi 2011. ISBN :81-219-0594-X
3	A Course in Electrical Power	Soni, M. L. Gupta, P.V. U.S. Bhatnagar,	Dhanpat Rai & Co. (P) Ltd., New Delhi 2016, ISBN: 9788177000207
4	Switchgear Protection and Power Systems	Sunil S. Rao	Khanna Publisher,New Delhi, 2008 ISBN: 978-8174092328
5	Elements of Electrical Power Station Design	Deshpande, M.V.	PHI Learning Pvt Limited, New Delhi, 2009, ISBN: 978-8120336476
6	Power Plant Engineering	Nagpal, G.R. S.C. Sharma,	Khanna Publishers-Delhi, 2012 ISBN :978-8174093097

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) http://nptel.iitm.ac.in
b) http://iitm.vlab.co.in/?sub=46&brch=144&sim=1056&cnt=4
c) http://www.edumedia-sciences.com
d) http://www.engineeringtv.com/video/Texas-Instruments
e) SEQUEL (open source)
f) PSIM
g) PSCAD