Program Name : Electrical Engineering Program Group

Program Code : EE/EP/EU

Semester : Fifth

Course Title : Illumination and Electrification of Buildings (Elective)

Course Code : 22530

1. RATIONALE

This course is intended to teach the students various aspects of Illumination scheme. Student will be in a position to apply principles and laws of Illumination and Illumination schemes. Students also have the knowledge of various types of lamps lighting accessories and control circuits. This will also enable them to use knowledge for preparing an Illumination scheme, requirement of the circuits, develop the skill of designing illumination scheme for specific applications. S/he will become aware of his role in adapting new changes in Illumination scheme necessitated due to technical innovations brought out by R and D in Illumination technology.

2. COMPETENCY

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

- **Design illumination schemes and associated electrification of buildings.**

3. COURSE OUTCOMES (COs)

The course content should be taught and learning imparted in such a manner that students are able to acquire required learning outcome in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

a) Select the relevant Illumination levels for various applications
b) Select relevant lamps for various applications
c) Select the lighting accessories required for selected wiring scheme.
d) Design a control circuit for Illumination
e) Design Illumination schemes for various applications
f) Interpret the Illumination scheme for various purposes.

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.

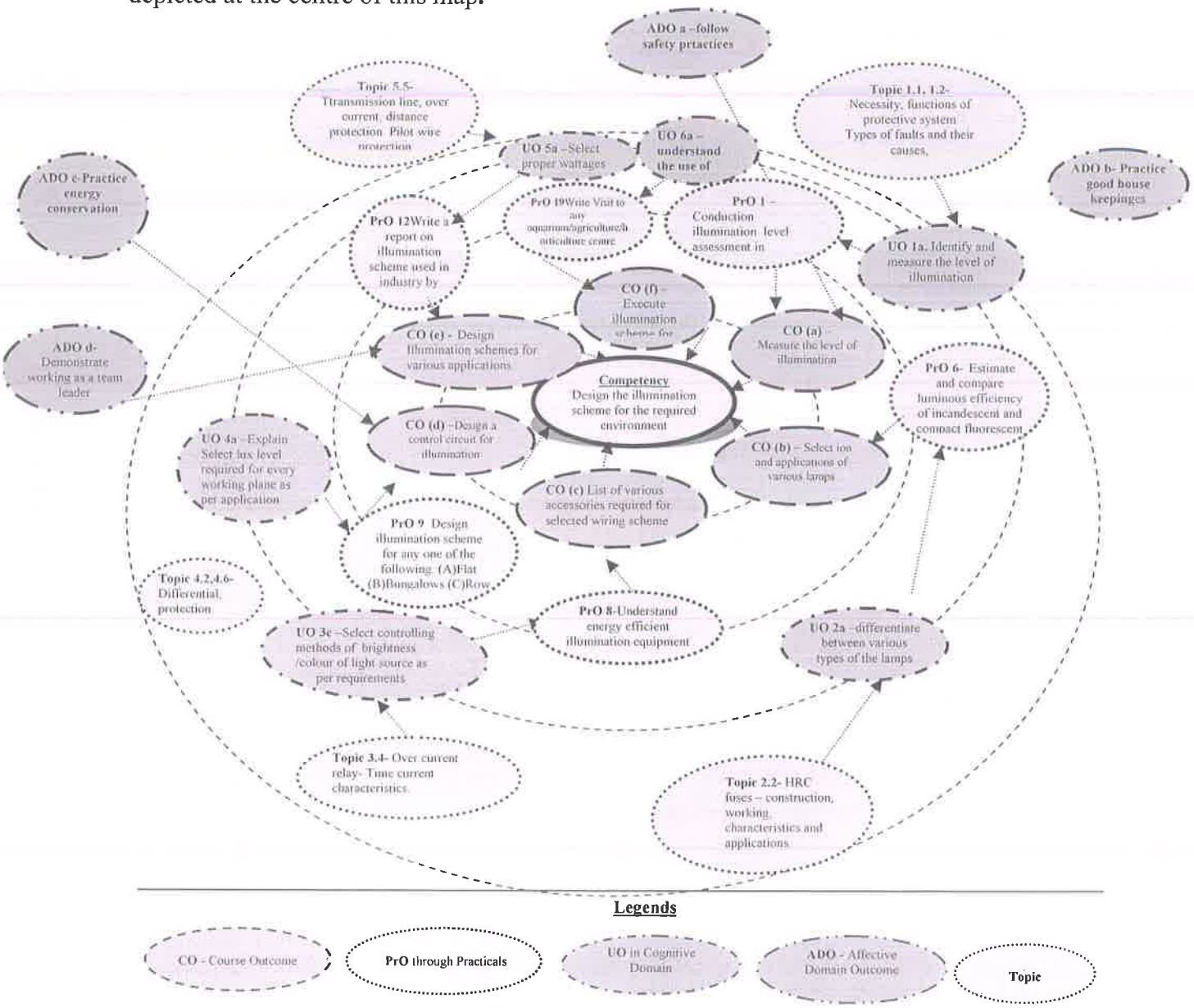

Figure 1 - Course Map

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	Conduct illumination level assessment in workplace using lux meter.	I	02*
2	Fit the given lamp in the selected mounting	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
3	Interpret the polar curves of the given type of lamp and verify it using the lux meter	I	02
4	Measure the illumination output of different lamps (Incandescent , Fluorescent,CFL) and compare it with their wattage.	II	02*
5	Measure the illumination output of different lamps (LED,HPSV, HPMV) and compare it with their wattage.	II	02
6	Measure illumination level with and without reflectors used in the various Luminaries.	II	02
7	Estimate and compare luminous efficiency of incandescent and compact fluorescent lamp.	II	02*
8	Prepare light dimmer arrangement using the relevant dimmer type of transformer	III	02*
9	Identify the given types of dimmer transformer and their parts	III	02
10	Build an electronic dimmer – Part I	III	02
11	Build another type of electronic dimmer – Part II	III	02
12	Build a single lamp control by single switch	III	02
13	Build a single lamp control by two switches	III	02
14	Build a single lamp control circuit for two point method	III	02
15	Build a lamp control circuit for three point method	III	02
16	Build a lamp control circuit for four point method	III	02
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting, collection of data and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.

c. Practice energy conservation.
d. 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
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Lux meter	1-4,6,9,12,16,18,19
2	Auto transformer	6,7
3	Control circuits for various Luminaries	7,8
4	Stroboscope	5
5	Wattmeter, voltmeter, ammeter, energy meter	8

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Fundamentals of illumination	1a Identify the illumination level required for the given situation with justification 1b Determine the wattage required for the given situation for the given data. 1c Interpret the polar curve of the given type of lamp. 1d Interpret with sketches the polar curve required for the given type of lamp. 1e Select the type and number of luminaires required for the given area in sq.m. with justification. 1f Prepare the lighting calculation of the given situation.	1.1 Basic illumination ,Terminology, Laws of illumination 1.2 Polar curves, polar curve: its meaning and applications for designing the lamp. 1.3 Concept of Photometry 1.4 Measurement of illumination 1.5 Lighting calculation methods a. Watt /m^2 method b. Lumens or light flux method c. Point to point method 1.6 Standards for illumination.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– II Types of lamps	2a Interpret with sketches the given type of lamp. 2b Explain the working of the given type of lamp 2c Select the relevant mounting arrangement for the given light source. 2d Compare the salient features of the given type of lamps.	2.1 Incandescent lamp 2.2 ARC lamps – AC and DC arc lamps 2.3 Fluorescent lamp 2.4 Types of other lamps: Mercury vapour lamp, HPMV lamp, Mercury iodide lamp, Sodium vapour lamp, LED, CFL, Halogen Lamps, Ultraviolet Lamps Neon Lamps. Neon Sign Tubes. Metal halides, Lasers 2.5 HID and Arc lamps 2.6 Selection Criteria for lamps
Unit-III Illumination Control and Control Circuits	3a. Select proper light source for given application. 3b. Select controlling methods of brightness/colour of light source for the given requirements. 3c. Explain with sketches the working of the given type of dimmer 3d. Design control circuit for Illumination 3e. Explain with sketches the given type of control circuit for lamps	3.1 Purpose of lighting control, and Dimmer, Resistance type Salt water Dimmer 3.1 Working principle and operation of Dimmer 3.2 Transformer and their types, Dimmer Transformer, Auto transformer dimmer, Two winding transformer dimmer 3.3 Electronic Dimmer: working principle and operation a) Thyrister operated dimmer b) Triac operated dimmer 3.4 Control of Enhance Lighting 3.5 Methods used for light control 3.6 Control circuits for lamps: single lamp controlled by single switch, two switches. 3.7 Single Lamp control by two point method, three point method and four point method 3.8 Control circuits for lamps (refer): ON/OFF control
Unit –IV Illumination for Interior Applications	4a. Select lux level required for given working plane as per application 4b. Calculate total lux level required for the given working plane 4c. Selection of proper light source with particular colour of light for the given situation 4d. Estimate the illumination scheme for the given type of residence.	4.1 Standard for various locations of Interior Illumination 4.2 Design considerations for Interior location of residences (1/2/3/4 BHK), Commercial, Industrial premises 4.3 Illumination scheme for different Interior locations of Residential, Commercial, industrial unit

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-V Lighting for Outdoor and Special Applications	5a. Select proper wattage for the given number of light sources for the given outdoor purpose 5b. Locate specific mountings of lighting sources for outdoor applications in specific environment 5c. Select relevant lamps in order to save energy for the given situation with justification 5d. State the safety measure and precautions to be followed for the given special purpose lamp.	5.1 Factory Lighting 5.2 Street Lighting (Latest Technology), Flood Lighting 5.3 Railway Lighting 5.4 Lighting for advertisement /Hoardings/sports lighting, Agriculture and Horticulture lighting, Health Care Centers / Hospitals, Decorating Purposes, Stage Lighting, Aquariums and Shipyards 5.5 Special purpose lamps used in photography video films.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of illumination	05	00	02	04	06
II	Types of lamps	12	04	06	06	16
III	Illumination Control and Control Circuits	12	04	06	06	16
IV	Illumination for Interior Applications	09	02	06	06	14
V	Lighting for Outdoor and Special Applications	10	04	04	10	18
	Total	**48**	**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 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 specifications of different illumination schemes used in various units and write a technical report.
b. Visit various units and take the help of unit in-charge to understand various illumination schemes.

c. Collect data of different illumination schemes used for residential, commercial industrial units and various places such as gardens, garages, substations etc.
d. Write all the safety precautions which are to be taken while working with different illumination schemes..
e. Collect data of Lightning schemes.
f. Study the IS codes implemented.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate subtopics with illumination schemes.

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) Collect Techno-commercial information of different lamps available in market (i. e. Lamp manufacture, technical specification, cost etc.)
b) **Installation and commissioning of a lighting structure :** Calculate load current and illumination level for certain lighting scheme.
c) **Case study of past installed illumination scheme and try to draw the polar curve..**
d) **Installation and commissioning of LED fixture.** Calculate load current and illumination level for certain lighting scheme
e) **Installation and commissioning of LED fixture for the specific purpose such as illuminating a statue.:** Prepare power point presentation for comparing the incandescent lamp scheme replaced by the LED structure.

f) **Stroboscopic effect visualization / color rendering index of a lamp.**Prepare the detailed schemes for measuring CRI.

13. SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1	Applied Illumination Engineering	Lindsey, Jack L.	The Fairmont Press Inc.
2	Lighting Engineering: Applied Calculations	Simons, R. H., Bean,Robert	Architectural Press (ISBN 0750650516)
3	Handbook of Applied Photometry	Casimer M Decusatis	Springer (ISBN 1563964163)
4	Handbook of Industrial Lighting	Butterworths, Lyons Stanley,	Butterworths
5	Lighting Control Technology and Applications	Simpson Robert S	Focal Press
6	Energy Management in Illuminating Systems	Kao Chen	CRC Press

14. SOFTWARE/LEARNING WEBSITES

a) www.archlighting.com
b) www.youtube.com /illumination engineering
c) www.megaman.cc/resources/lighting-design/lighting software
d) www.nptelvideos.in/electrical engineering/ lamps
e) www.electrical4u.com
f) www.NPTEL.com

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 : **Fifth**

Course Title : **Capstone Project – Planning**

Course Code : **22058**

1. RATIONALE

According to the requirement of National Board of Accreditation (NBA), 'learning to learn' is an important Graduate Attribute (GA No.11). It is required to develop this skill in the students so that they continue to acquire on their own new knowledge and skills from different 'on the job experiences' during their career in industry. An educational 'project' just does that and may be defined as ***'a purposeful student activity, planned, designed and performed by a student or group of students to solve/ complete the identified problem/task, which require students to integrate the various skills acquired over a period to accomplish higher level cognitive and affective domain outcomes and sometimes the psychomotor domain outcomes as well'***. Projects mainly serve this purpose of developing learning-to-learn skills with an aim to develop the following attributes in the students:

a) Initiative, confidence and ability to tackle new problems
b) Spirit of enquiry
c) Creativity and innovativeness
d) Planning and decision making skills
e) Ability to work in a team and to lead a team
f) Ability of self directed learning which is required for lifelong learning
g) Persistence (habit of not giving up quickly and trying different solutions in case of momentary failures, till success is achieved)
h) Resourcefulness
i) Habit of keeping proper records of events and to present a formal comprehensive report of their 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:

- **Plan innovative/creative solutions independently and/or collaboratively to integrate various competencies acquired during the semesters to solve/complete the identified problems/task/shortcomings faced by industry/user related to the concerned occupation.**

3. COURSE OUTCOMES (COs)

The following could be some of the major course outcomes depending upon the nature of the projects undertaken. However, in case of some projects few of the following course outcomes may not be applicable.

a) Write the problem/task specification in existing systems related to the occupation.
b) Select, collect and use required information/knowledge to solve the problem/complete the task.
c) Logically choose relevant possible solution(s).
d) Consider the ethical issues related to the project (if there are any).
e) Assess the impact of the project on society (if there is any).
f) Prepare 'project proposals' with action plan and time duration scientifically before beginning of project.

g) Communicate effectively and confidently as a member and leader of team.

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
-	-	2	2	--	--	--	--	--	--	--	25@	10	25	10	50	20

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

5. Capstones Project

One of the dictionary meaning is the 'crown' or the stone placed on top of the building structure like 'kalash on top of Temples and Mosques' or 'Cross on top of churches'. Capstone projects are culminating experiences in which students synthesize the competencies acquired over whole programme. In some cases they also integrate cross-disciplinary knowledge. Thus Capstone projects prepare students for entry into a career and can be described as a 'rite of passage' or 'minimal threshold' through which participants change their status from student to graduate. A capstone project therefore should serve as a synthesis — reflection and integration— to bridge the real-world preparatory experience to real life. Thus capstone project should have emphasis on integration, experiential learning, and real-world problem solving and hence these projects are very important for students. To develop the highly essential industry oriented skills and competencies in the students, the capstone projects are offered in the last two semesters to serve for following purposes:

a) Integrate the competencies acquired by the students in the previous and current semesters.
b) Provide opportunities for interdisciplinary work in tackling problems likely to be faced by them in industry which are exciting and challenging.

6. Capstone Project Planning

Students are supposed to find out a suitable project and prepare a detailed plan in fifth semester so that it can be executed smoothly in sixth semester. The main characteristic of any project whether small or big is that it requires simultaneous application of various types of skills in the different domains of learning. Moreover, project normally do not have a predefined single solution, in other words for the same problem different students may come up with different but acceptable solutions. Further, in the process of arriving at a particular solution, the student must be required to make a number of decisions after scrutiny of the information s/he has accumulated from experiments, analysis, survey and other sources.

The projects will have a detailed project proposal, which must be executed or implemented within the time allocated, simultaneously maintaining a logbook periodically monitored by the teacher. A detailed project report is to be prepared as project progresses, which has to be submitted after the project is over. For self assessment and reflection students have to also prepare a portfolio of learning.

During the guidance and supervision of the project work, teachers' should ensure that students acquire following ***learning outcomes*** (depending upon the nature of the project work some of these learning outcomes may not be applicable):

a) Show the attitude of enquiry.
b) Identify the problems in the area related to their programme.
c) Identify the information suggesting the cause of the problem and possible solutions.
d) Assess the feasibility of different solutions and the financial implications.

e) Collect relevant data from different sources (books/internet/market/suppliers/experts etc. through surveys/interviews).
f) Prepare required drawings and detailed plan for execution of the work.
g) Work persistently and participate effectively in group work to achieve the targets.
h) Work independently for the individual responsibility undertaken.
i) Ask for help from others including guide, when required.
j) Prepare portfolio to reflect *(chintan-manan)* on experiences during project work.
k) Prepare seminar presentations to present findings/features of the project.
l) Confidently answer the questions asked about the project.
m) Acknowledge the help rendered by others in success of the project.

If students are able to acquire these *learning outcomes*, then they would be able to acquire the COs as discussed in section 3.

7. Scopes of Projects

Scope of the project work should be decided based on following criteria:

a) Relation to diploma programme curriculum: When students intend to select topics for the project work they need to choose a project which relates well to their curriculum (It may be beyond curriculum, but it should relate to it) and requires implementation of theories already learnt and skills already possessed by them from the previous semesters.

b) Abilities possessed by the group of students: Projects should be chosen so that it can be completed mainly using students' problem solving capabilities and depth of learning. It is natural that highly motivated students or high achievers may come out with projects which are more complex and challenging. Teachers should guide students to choose challenging projects according to the students' ability.

c) Resources Available: Students and Guides should keep in mind the availability of resources while deciding the topic and the scope of the project. Some of the important resources which need consideration are:

i. Time available
ii. Raw Material/Components required
iii. Manufacturing/Fabrication equipment and tools required
iv. Testing/Measuring equipment and instruments required
v. Access to Journals (Library/Digital)
vi. Expertise for theoretical guidance (available in polytechnic, nearby institutes or nearby industries)
vii. Expertise and technology required for fabrication (if required)
viii. Software required.

An important aspect to be considered is to decide who will choose a project. The best practice is that teacher should guide students about the above factors to be considered for choosing the project and based on these factors students should do the ground work and identify the possible projects and teachers should work as only facilitator and Guide in final selection of the project title and its scope.

d) Suggested Type of Capstone Projects

In general, the projects that the students can take up could be of the following types;

i. Feasibility studies.
ii. Design projects
iii. Market surveys about raw material, components or finished products.
iv. Prototype (design, make, test and evaluate).
v. Advanced experimental work requiring the development of existing equipment to be used and developed.
vi. Field works: This could include surveys, using equipment, charting data and information from visual observation.

vii. Comparative Studies: Theoretical study of two systems/mechanisms/ processes in detail and comparing them on the basis of cost/energy conservation/impact on environment/technology used etc.
viii. Application of Emerging technology: Theoretical study of some emerging technology and feasibility of its application in some real life situation in detail.
ix. Fabrication of some equipment/machine etc.
x. Construction of some structure.
xi. Development of software or use of software for solving some broad-based problem.

8. GUIDELINES FOR UNDERTAKING A PROJECT

The selection of the *Capstone Project title* must have emphasis to the Elective courses/ Elective Group taken for the study and exam for 5th and 6th semester. The students will then work on the identified problem/task through a rigorous process of understanding and analyzing the problem, conducting a literature search, deriving, discussing (monitored by the guide every fortnight) and designing the ***Semester V 'Project Proposal'*** with the following ***sub-titles***:

a) Rationale (one page)
b) Introduction
c) Literature Survey
d) Problem Definition
e) Proposed Methodology of solving Identified problem
f) In-case some prototype has to be fabricated then its tentative design and procedure for making it should be part of the proposal.
g) Resources and consumables required.
h) Action Plan (sequential list of activities with probable dates of completion)

As soon as the 'Project Proposal' is approved by the teacher, the student will begin to maintain a dated ***'Project Logbook'*** 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 logbook'* should be got signed by the teacher at regular intervals for progressive assessment to match the project proposal. If this is maintained sincerely and truthfully by the student, it will be very helpful in compiling the 'Project Report' at the end of the semester by him/her.

9. PORTFOLIO FOR SELF-DIRECTED LEARNING

To ensure that students acquire these outcomes, students should also be guided to prepare a **'Portfolio'**, so that they may reflect on their weaknesses/mistakes and learn from them. ***Students should also be encouraged to discuss with their guide and record not only technical problems but also problems related to group work, planning, execution, leadership in the team etc., so that students can also identify their weaknesses in affective domain and take remedial actions to overcome the same.*** If they wish, the students can also show their portfolio to their teachers (whom they trust) for obtaining teachers' comments on their reflection for pointing out their mistakes so that they can improve their performance.

'Portfolio' is the record of the reflection (thinking or *chintan-manan*) on experiences to which students undergo during the different stages of the project. In a portfolio, students record their critical experiences and reflect (think or do *chintan-manan*) on them in writing. This process of reflecting on the experiences make them learn from their mistakes and build on their strengths. To help students in reflection, a Portfolio format with reflective prompts (simple thought provoking questions) for different stages of the project is given as annexure B.

12.1 Purposes of Portfolio Preparation

Reflection by self is important since group work is so complex that it is difficult for teachers to appreciate the real problems amongst the students. In a portfolio, prompts (simple thought provoking questions) are given to trigger reflection on different aspects of project work. Prompts help the students to ask questions from themselves regarding different aspects of the project work and interpersonal relationships. Process of answering these questions forces students to think about behavioral problems and possible remedies/solution to deal with those problems. Portfolio preparation therefore helps in reflection on building the strengths and elimination of the weaknesses of the students pertaining to following qualities which the industry also need.

a) Plan properly for execution of given work.
b) Take appropriate decisions.
c) Arrange resources.
d) Work as member and leader of team.
e) Communicate properly.
f) Resolve the conflicts.
g) Manage the time well.
h) Have concern for ethical, societal and environmental issues.
i) Learn-to-learn from experiences.

It may be seen that these qualities are not directly related with the theoretical subject knowledge and can be developed only through real life experiences. Project work is one such type of experience where opportunity is available to develop all these qualities.

However, even during project work, emphasis of most of the students and teachers remains on development of the technical knowledge and skills while development of above qualities is neglected. Students can develop these qualities if they reflect (do thinking or *Chintan-Manan*) on their experiences from the point of view of these qualities and find out their own weaknesses and strengths. Because if somebody wants to improve his/her abilities then first step for that person is to have self awareness about his/her weaknesses and strengths.

Though portfolio preparation requires considerable time, it is essential, if we want to learn from the experiences and develop these qualities. Writing down reflections helps in better reflection as it is well known that when a person starts writing something he/she becomes more cautious about his/her view and evaluate those views before writing. Thus process of writing improves the quality of reflection or thinking. Moreover, if reflections on different stages of work are written down, over a period of time a large amount of reflection can be generated, and if this reflection is looked back, it may help in identifying some pattern of behaviour in individual which may be improved or rectified latter on as per requirement.

12.2 Guidelines for Portfolio Preparation and assessment

The main purpose of portfolio preparation is learning based on self-assessment and ***portfolio is not to be used for assessment in traditional sense.***

a) Each student has to prepare his/her portfolio separately. However, he/she can discuss with the group members about certain issues on which he/she wants to write in the portfolio.
b) For fifth semester and sixth semester, there will be only one portfolio but it will have two separate parts, first part for project planning (having two sections A and B) second part for project execution. (having two sections C and D)
c) Whatever is written inside the ***portfolio is never to be used for assessment***, because if teachers start giving marks based on whatever is written in the portfolio, then students would hesitate in true self-assessment and would not openly describe their own mistakes or shortcomings.

d) Some marks are allocated for portfolio, these marks are to be given based on how sincerely portfolio has been prepared and not based on what strengths and weaknesses of the students are mentioned in the portfolio.
e) Portfolio has to be returned back to the students after assessing it (assessment is only to see that whether portfolio is completed properly or not) by teachers. Because student is the real owner of the portfolio.
f) Students mainly learn during portfolio preparation, but they can further learn if they read it after a gap. And hence they are supposed to keep the portfolios with them even after completion of the diploma because it is record of their own experiences (it is like diary some people write about their personal experiences), because they can read it again after some time and can revise their learning (about their own qualities)

Even after completion of Diploma programme, students can continue to prepare portfolio related to different experiences in their professional and personal life and by refereeing back to old portfolios after a gap of some years, they can learn that how their personality has evolved over the years. They can also see a pattern of behaviour in their own personality which may be source of their weaknesses or strengths and they can take remedial measures based on this study of their portfolios.

Note

Since some sections of the portfolio are related with interpersonal relationships and student may find it difficult to write these experiences in English. Language should not be the barrier in reflection and hence students should be allowed to prepare the portfolio in their preferred language such as *Marathi* or *Hindi if they find it difficult to write in English.*

The amount and type of mistakes identified by students would not affect the marks received by the students. The total 7 Marks allocated for portfolio (4 marks for PA and 3 for ESE) are only for proper completion of the portfolio.

10. PROJECT REPORT

At the end of fifth Semester, the student will prepare a Semester V 'Project Report' with the following sub-titles:

- Certificate (in the Format given in this document as annexure A)
- Acknowledgements
- Abstract (in one paragraph not more than 150 words)
- Content Page
- Chapter-1 Introduction and background of the Industry or User based Problem
- Chapter-2 Literature Survey for Problem Identification and Specification,
- Chapter-3 Proposed Detailed Methodology of solving the identified problem with action plan
- References and Bibliography

Note: The report should contain relevant diagrams and figures, charts.

11. ASSESSMENT OF CAPSTONE PROJECT – PLANNING

Like other courses, assessment of Project work also has two components, first is progressive assessment, while another is end of the term assessment. The mentor faculty will undertake the progressive assessment to develop the COs in the students. They can give oral informal feedback about their performance and their interpersonal behaviour while guiding them on their project work every week. The following characteristics/ qualities informally or formally should be considered during different phases of the project work which will be assessed thrice as discussed in sub-section.

(A) Initial Phase

i. **Definition of the Problem**
   a) Accuracy or specificity

b) Appropriateness with reference to desired course outcomes.

ii. **Methodology of Conduction the Project**
   a) Appropriateness
   b) Flexibility
   c) Clarity

iii. **General Behaviour**
   a) Initiative
   b) Resourcefulness
   c) Reasoning ability
   d) Imagination/creativity
   e) Self-reliance

(B) Intermediate Phase

i. **Performance of Student**
   a) Ability to follow correct procedure
   b) Manipulative skills
   c) Ability to collect relevant information
   d) Ability to observe, record & interpret
   e) Ingenuity in the use of material and equipment
   f) Target achievement

ii. **General Behaviour**
   a) Persistence
   b) Interest
   c) Commitment
   d) Confidence
   e) Problem solving ability
   f) Decision making ability
   g) Initiative to act
   h) Team spirit.
   i) Sharing of material etc.
   j) Participation in discussion
   k) Completion of individual responsibilities

(C) Final Phase

i. **Quality of Product**
   a) Dimensions
   b) Shape
   c) Tolerance limits
   d) Cost effectiveness
   e) Marketability
   f) Modernity

ii. **Quality of Report**
   a) Clarity in presentation and organization
   b) Styles and language
   c) Quality of diagrams, drawings and graphs
   d) Accuracy of conclusion drawn
   e) Citing of cross references
   f) Suggestion for further research/project work

iii. **Quality of presentation**
   a) Understanding of concepts, design, methodology, results, implications etc
   b) Communication skills
   c) Ability to draw conclusions and generalization

12. PROGRESSIVE ASSESSMENT (PA) GUIDELINES

15 Marks are allocated for the formal progressive assessment. However, following points need consideration during the three times of formal progressive assessment of the students at the end of 4th, 12th and 14th week.

a) ***Fortnightly monitoring*** by the mentoring teachers is necessary and marks given progressively (even the gradual chapter preparation) so that that students will not copy earlier reports or get things done or reports from the market. The ***students should not be awarded marks*** if they have not done on their own.

b) For progressive assessment at the end of 14th week, 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 capstone project work they have to carry out in future).

c) Although marks for *portfolio preparation* is to be given at the end of 14th week, students should be asked to bring their partly prepared portfolio (relevant sections prepared) also during their assessment at the end of 4th week and 12th week.

d) Marks for portfolio preparation should be based only on proper preparation of portfolio by writing answers to most of the prompts (self-questions to students) in the portfolio. These marks should not be based on the mistakes indicated by students in their working (while answering the prompts) and corrective actions taken by them.

e) 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.)

f) ***Originality of the report*** (written in own words) would be given more importance rather than use of glossy paper or multi-colour printing.

12.1 Progressive Assessment (PA) Criteria

Allocation Criteria of the ***25 marks*** are for the Progressive Assessment (PA).

S. No.	Criteria	Marks
	First Progressive Assessment at the end of 4th week	
1	**Problem Identification/Project Title** (Innovation /Utility of the Project for industry/ User/Academia) marks to be also given based on (i) Accuracy or specificity of the scope and (ii) Appropriateness of the work with reference to desired course outcomes.	02
2	**Industrial Survey and Literature Review**: marks to be given based on extent/volume and quality of the survey of Industry / Society / Institutes/Literature/Internet for Problem Identification and possible solutions	02
3	**General Behaviour**: initiative, resourcefulness, reasoning ability, imagination/creativity, self-reliance to be assessed **Note:** Oral feedback on general behaviour may also be given whenever relevant/ required during day to day guidance and supervision. **Only written feed-back/suggestions**	**00**
	Second Progressive Assessment at the end of 12th week	
4	**Project Proposal**: Marks to be given also based on appropriateness, flexibility, detail and clarity in methods/planning. (In case of working models, detailed design and planning of fabrication/assembly of the prototype has to be also assessed). This proposal should include whole project including work to be done in sixth semester	**03**

S. No.	Criteria	Marks
5	**Execution of Plan in fifth semester** (Since project is to be fully completed in sixth semester, the part of the project which is planned to be completed in fifth semester is only to be evaluated: marks to be also given based on ability to collect relevant information, ability to follow correct procedure, manipulative skills, ability to observe, record & interpret, ingenuity in the use of material and equipment, target achievement) In case of working models, quality of workman ship (including accuracy in dimensions, shape, tolerance limits), appropriateness of raw materials/components/ technology being used, functioning of the prototype, cost effectiveness, marketability, modernity etc. has to be also assessed.	02
6	**Log book** (for work done in fifth semester, detailed and regular entry would be basis of marks)	02
7	**General Behaviour** (persistence, interest, confidence, problem solving ability, decision making ability, initiative to act, team spirit, sharing of material etc., participation in discussions, completion of individual responsibilities, leadership) **Note:** Oral feedback on general behaviour should also be given whenever relevant/ required during day to day guidance and supervision. **Only written feed-back./suggestions**	00
	Third Progressive Assessment at the end of 14th week	
8	**Portfolio for Self learning and reflection** (marks based on amount of reflection and completion of the portfolio for work done in fifth semester)	**04**
9	**Final Report writing including documentation**. (marks based on: clarity in presentation and organization; styles and language; quality of diagrams, drawings and graphs; accuracy of conclusion drawn; citing of cross references; suggestion for further research/project work) Report has to be prepared for work done in fifth semester and planning for sixth semester work.	**06**
10	**Presentation** (presentation skills including communication skills to be assessed by observing quality of presentations and asking questions during presentation and viva/voce) Report has to be prepared for work done in fifth semester and plan for sixth semester.	**02**
11	**Defence** (ability to defend the methods/materials used and technical knowledge, and involvement of individual to be assessed by asking questions during presentation and viva/voce)	**02**
	Total	**25**

13. END-SEMESTER-EXAMINATION (ESE) ASSESSENT GUIDELINES

The ***remaining 25 marks*** are for the end-semester-examination (ESE). And marks would be given according to following criteria. Moreover, the suggested evaluation scheme can be changed slightly by the external faculty according to nature of problem / project following University guidelines..

a) For each project, the one or two students from the concerned group of students should be asked to present the power point presentation before the external and internal (for about 10 minutes) and then external should ask the questions from each member of the group separately to ascertain the contribution made by each student.

b) 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 commensurate with their efforts.)

c) The students would not be awarded marks if they have completed the project by getting done the work from market or some professionals (taking help and guidance is different as compared to getting the work or maximum part of the work completed from others on payment basis).

d) Originality of the report (written in own words, even if there are grammatical and spelling mistakes) would be given more importance rather than quality of printing and use of glossy paper (and preparing report by copy pasting from other reports).

Note: It is very common that people are not able to complete the project in time despite best of their efforts. (Please recall that how many times people are able to complete in time, personal projects such as building own house or professional projects such as developing the lab in the institute). So if students have put in enough genuine efforts but could not complete the project in time then we should consider it sympathetically and they should be given marks based on their efforts and they should get more marks as compared to students who have got their projects completed by taking major help from others/market.

13.1 End-Semester-Examination (ESE) Assessment Criteria.

Allocation Criteria of the ***25 marks*** are for the end-semester-examination (ESE)

S. No.	Description	Marks
1	**Problem Identification/Project Title** (innovation /utility of the project for industry/ user/academia) marks to be also given based on (i) accuracy or specificity of the scope and (ii) appropriateness of the work with reference to desired course outcomes.	**02**
2	**Industrial Survey and Literature Review** (marks to be given based on extent/volume and quality of the survey of industry / society / institutes/literature/internet for problem identification and possible solutions)	**02**
3	**Project Proposal**: Marks to be given also based on appropriateness, flexibility, detail and clarity in methods/planning. (In case of working models, detailed design and planning of fabrication/assembly of the prototype has to be also assessed). This proposal should include whole project including work to be done in sixth semester.	**02**
4	**Execution of Plan in fifth semester** (Since project is to be fully completed in sixth semester, the part of the project which is planned to be completed in fifth semester is only to be evaluated: marks to be also given based on ability to collect relevant information, ability to follow correct procedure, manipulative skills, ability to observe, record & interpret, ingenuity in the use of material and equipment, target achievement) In case of working models, quality of workman ship (including accuracy in dimensions, shape, tolerance limits), appropriateness of raw materials/components/ technology being used, functioning of the prototype, cost effectiveness, marketability, modernity etc. has to be also assessed.	**02**
5	**Log book** (for work during fifth semester, marks to be given based on detailed and regular entry	**03**
6	**Portfolio for Self learning and reflection** (for work during fifth semester) Marks based on amount of reflection and completion of portfolio.	**03**
7	**Project Report including Documentation** (for work during fifth semester and planning for sixth semester) (marks based on: clarity in	**04**

S. No.	Description	Marks
	presentation and organization; styles and language; quality of diagrams, drawings and graphs; accuracy of conclusion drawn; citing of cross references; suggestion for further research/project work)	
8	**Presentation** (presentation skills including communication skills to be assessed by observing the quality of presentations and asking questions during presentation and viva/voce) Presentation should be based on work done in fifth semester and planning for sixth semester.	**03**
9	**Defence** (ability to defend the methods/materials used and technical knowledge, and involvement of individual to be assessed by asking questions during presentation and viva/voce)	**04**
	Total	**25**

14. 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 guide students in selecting a topic which is relevant and challenging (but within capacity) for students according to their abilities.

c) 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.

d) Teachers should motivate students to maintain log book and prepare portfolio. 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.

e) Teachers should also encourage students to openly discuss their weaknesses and shortcomings in portfolio and teachers should develop confidence in students that admitting mistakes and weaknesses helps in improving them and their marks would not be affected by revealing their mistakes. Marks related to portfolio are awarded based only on the sincerity with which it is prepared and not based on strengths and weaknesses of students.

f) 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.

g) 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.

Annexure A

CERTIFICATE

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

From .....College having Enrolment No: .....

has completed ***Report on the Problem Definition/ Semester V Project Report/ Final Project Report*** having title .....

individually/ in a group consisting of..... persons under the guidance of the Faculty Guide.

.....
The mentor from the industry for the project
Name: .....
Telephone:.....

Annexure B

Portfolio for Self Directed Learning for Major Project Work

Name of Student:.....

Semester:.....Programme/Branch:.....

Roll Number:.....

Title of the Project:.....

Name and Designation of Project Guide:.....

Name of Polytechnic:.....

Part A: Selecting the Project and Team (Answers to the following questions to be included in 'Portfolio' as Reflection related to formation of group and finalization of project topic).

Note: This section has to be prepared just after the finalization of the Project topic and formation of the Project Team .

1. How many alternatives we thought before finalizing the project topic?
2. Did we consider all the technical fields related to branch of our diploma programme?
3. Why we found present project topic as most appropriate?
4. Whether all the group members agreed on the present project topic? If not? What were the reasons of their disagreements?
5. Whether the procedure followed in assessing alternatives and finalizing the project topic was correct? If not, discuss the reasons.
6. What were the limitations in other alternatives of project topic?
7. How we formed our team?
8. Whether we faced any problem in forming the team? If yes, then what was the problem and how was it resolved?

9. Am I the leader of our project team? If yes, then why was I chosen? If not, why I could not become the project team leader?
10. Do I feel that present team leader is the best choice available in the group? If yes, then why? If not, then why?
11. According to me who should be the leader of the team and why?
12. Can we achieve the targets set in the project work within the time and cost limits?
13. What are my significant good/ bad sharable experiences while working with my team which provoked me to think? What I learned from these experiences?
14. Any other reflection which I would like to write about formation of team and finalization of project title, if any?

Part B: Reflection related to project planning (Answers to the following questions to be included in 'Portfolio' as reflection on planning)

Note: This section has to be prepared just after the finalization of the 'Project Proposal'.

1. Which activities are having maximum risk and uncertainty in our project plan?
2. What are most important activities in our project plan?
3. Is work distribution is equal for all project group members? If not? What are the reasons? How we can improve work distribution?
4. Is it possible to complete the project in given time? If not what are the reasons for it? How can we ensure that project is completed within time.
5. What extra precaution and care should be taken in executing the activities of high risk and uncertainty? If possible, how such risks and uncertainties can be reduced?
6. Can we reduce the total cost associated with the project? If yes, then describe the ways?
7. For which activities of our project plan, arrangement of resources is not easy and convenient?
8. Did we make enough provisions of extra time/expenditure etc. to carry out such activities?
9. Did we make enough provisions for time delays in our project activity? In which activities there are more chances of delay?
10. In our project schedule, which are the days of more expenditure? What provisions we have made for availability and management of cash?
11. Any other reflection which I would like to write about project planning?

Teacher Evaluation Sheet (ESE)
for
Capstone Project Planning

Name of Student: .....

Name of Programme..... **Semester:** .....

Course Title and Code:.....

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

a) Unit Outcomes (Cognitive Domain)

i. .....
ii. .....
iii. .....
iv. .....

b) Practical Outcomes (in Psychomotor Domain)

i. .....
ii. .....
iii. .....
.....
iv. .....
.....

c) Affective Domain Outcomes

i. .....
ii. .....
iii. .....
iv. .....

D. SUGGESTED RUBRIC FOR ASSESSMENT OF CAPSTONE PROJECT

(please tick below the appropriate rating i.e. poor, average etc., for each characteristic to be assessed and give marks in the respective cell according to performance of student)

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
First Progressive Assessment (at the end of 4th week)							

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
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	i. Take care of more than three POs ii. Scope of problem/task very clear	02	
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	02	
	Second Progressive Assessment (at the end of 12th week)						
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)	02	
4	**Execution of Plan in fifth semester (please write by hand about students performance in appropriate column)**					02	
5	**Log Book**	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	03	
	Third progressive Assessment at the end of 14th week						
6	Portfolio Preparation	Answer to only few of the 'questions from self' (prompts)	Answer to only about 50% of the 'questions from self'	Answer to most of the 'questions from self' (prompts) written. Some	Answer to nearly all the 'questions from self' (prompts) written in detail	03	

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent	Max. Marks	marks obtained
		written. Answers are not in much detail	(prompts) written. Answers are not in much detail	answers are not in much detail			
7	**Final Report Preparation**	Very short, poor quality sketches, Details about methods, material, precaution and conclusions omitted, some details are wrong Nearly sufficient and correct details about methods, material, precautions and conclusion. but clarity is not there in presentation, not enough graphic description.	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, charts and sketches	**04**	
8	**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	**03**	
9	**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	**04**	
					Total marks	**25**	

Any Other Comment:

.....

.....

Name and designation of the Faculty Member.....**Signature**.....

.....

Program Name : **Diploma in Mechanical Engineering / Electrical Engineering Group / Chemical Engineering / Plastic Engineering**

Program Code : **ME / EE / EP / EU / CH / PS**

Semester : **Fifth**

Course Title : **Management**

Course Code : **22509**

1. RATIONALE

An engineer has to work in industry with human capital and machines. Therefore, managerial skills are essential for enhancing their employability and career growth. This course is therefore designed to provide the basic concepts in management principles, safety aspects and Industrial Acts.

2. COMPETENCY

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

- **Use relevant managerial skills for ensuring efficient and effective management.**

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. Use basic management principles to execute daily activities.
b. Use principles of planning and organising for accomplishment of tasks.
c. Use principles of directing and controlling for implementing the plans.
d. Apply principles of safety management in all activities.
e. Understand various provisions of industrial acts.

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	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--

(*#) Online Theory Examination.

(*): 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.(#): Online examination*

***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.

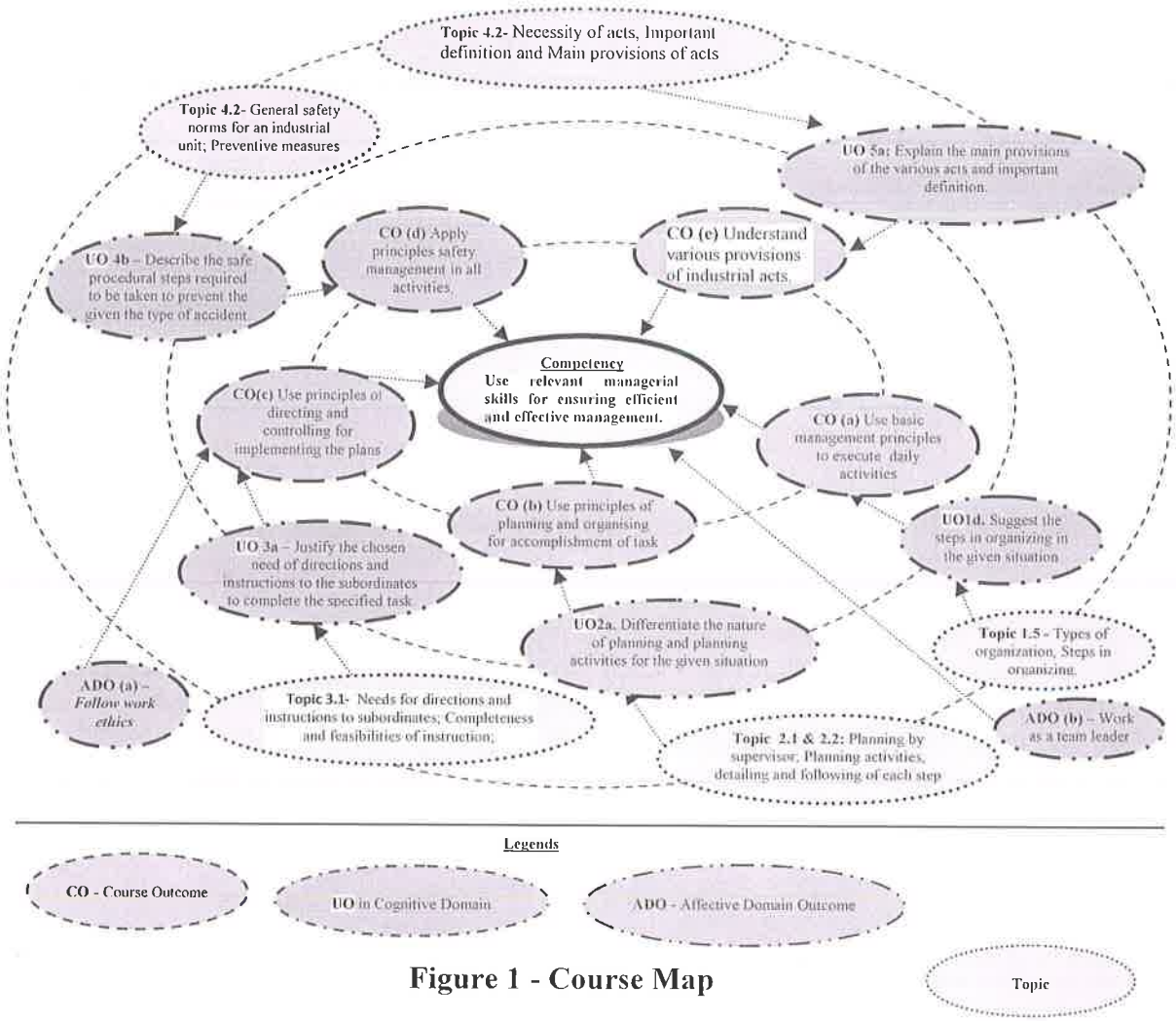

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

- Not applicable -

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

- Not applicable -

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 Introduction to management concepts and managerial skills	1a. Differentiate the concept and principles of management for the given situation. 1b. Explain functions of management for given situation. 1c. Compare the features of the given types of planning 1d. Suggest the steps in organizing in the given situation. 1e. Suggest suitable type of organization for the given example. 1f. Identify the functional areas of management for the given situation 1g. Suggest suitable managerial skills for given situation with justification	1.1 Definitions of management, role and importance of management. 1.2 Management characteristics and principles, levels of management and their functions; management, administration and organization, relation between management and administration. 1.3 Functions of management: planning, organizing, leading/directing, staffing and controlling. 1.4 Types of planning and steps in planning 1.5 Types of organization, Steps in organizing 1.6 Functional areas of management. 1.7 Managerial skills.
Unit – II Planning and organizing at supervisory level	2a. Differentiate the nature of planning and planning activities for the given situation. 2b. Suggest the step wise procedure to complete the given activity in the shop floor. 2c. Prepare materials and manpower budget for the given production activity. 2d. Describe with block diagrams the organization of the physical resources required for the given situation. 2e. Describe the human needs to satisfy the job needs for the specified situation. 2f. List the tasks to be done by the concerned individuals for completing the given activity.	**Planning at supervisory level** 2.1 Planning by supervisor. 2.2 Planning activities, detailing and following of each step. 2.3 Prescribing standard forms for various activities. 2.4 Budgeting for materials and manpower. **Organizing at supervisory level** 2.5 Organizing the physical resources. 2.6 Matching human need with job needs. 2.7 Allotment of tasks to individuals and establishing relationship among persons working in a group
Unit– III Directing and Controlling at supervisory level	3a. Justify the chosen need of directions and instructions to the subordinates to complete the specified task. 3b. Select the feasible set of instructions to complete the given simple task, with justification 3c. Predict the possible mistakes for completing the given simple activity. 3d. Describe the managerial control	**Directing at supervisory level** 3.1 Needs for directions and instructions to subordinates; Completeness and feasibilities of instructions 3.2 Personal counselling advanced predictions of possible mistakes. 3.3 Elaborating decisions, laying disciplinary standards in overall working **Controlling at supervisory level**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	actions and remedial measures required to be taken for completing the given task successfully.	3.4 Managerial control; Understanding team and link between various departments in respect of process and quality standards; Steps in control process 3.5 Controlling methods; Control over the performance in respect of quality, quantity of production, time and cost. Measuring performance, comparing with standards, correcting unfavorable deviations.
Unit – IV Safety Management	4a. State the general safety norms required to be taken in the given case. 4b. Suggest preventive measures of plant activities in the given situation. 4c. Describe the safe procedural steps required to be taken to prevent the given the type of accident. 4d. Prepare a work permit in to conduct the given maintenance activity. 4e. Explain the causes of the specified type of accident in the given situation. 4f. Prepare the specifications of the firefighting equipment required for the given type of fire.	4.1 Need for safety management measures 4.2 General safety norms for an industrial unit; Preventive measures. 4.3 Definition of accident, types of industrial accident; Causes of accidents; 4.4 Fire hazards; Fire drill. 4.5 Safety procedure 4.6 Work permits.
Unit – V Legislative Acts	5a. Explain the purpose of the act 5b. Explain the main provisions of the various acts and important definition.	5.1 Necessity of acts, Important definition and Main provisions of acts. 5.2 Industrial Acts: a. Indian Factory Act b. Industrial Dispute Act c. Workman Compensation Act d. Minimum Wages Act

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	Introduction to management	12	06	06	04	16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	concepts and managerial skills					
II	Planning and organizing at supervisory level	08	04	06	04	14
III	Directing and controlling at supervisory level	08	04	06	04	14
IV	Safety Management	08	04	06	04	14
V	Legislative Acts	12	02	06	04	12
Total		**48**	**20**	**30**	**20**	**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. Write assignments based on the theory taught in classrooms. Assignments consist of ten questions having long answers including charts, symbols, drawing, observations etc.
b. Prepare/Download information about various industrial acts.
c. Visit to any Manufacturing industry and prepare a report consisting of:
    i. Organization structure of the organization/ Dept.
    ii. Safety measures taken in organization.
    iii. Mechanism to handle the disputes.
    iv. Any specific observation you have noticed.
d. Give seminar on relevant topic.
e. Undertake micro-projects.

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. Demonstrate students thoroughly before they start doing the practice.

g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in Lab.

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. Study of management principles applied to a small scale industry.
b. Study of management principles applied to a medium scale industry.
c. Study of management principles applied to a large scale industry.
d. Prepare case studies of Safety measures followed in different types of organization.
e. Study of measures to be taken for ensuring cyber security.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Management and entrepreneurship	Veerabhadrappa, Havinal	New age international publishers, New Delhi, 2014: ISBN: 978-81-224-2602-1
2	Principles of management	Chaudhry omvir Singh prakash	New Age international publishers, 2012, New Delhi ISBN: 978-81-224-3039-4
3	Industrial Engineering and management	Dr. O. P. Khanna	Dhanpath ray and sons, New Delhi
4	Industrial Engineering and management	Banga and Sharma	Khanna Publication, New Delhi

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.versesolutions.com/
b. https://www.books.google.co.in/books?isbn=817758412X
c. https://www. www.educba.com › Courses › Business › Management

Program Name : **Electrical Engineering Program Group**

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

Semester : **Fifth**

Course Title : **Industrial AC Machines**

Course Code : **22523**

1. RATIONALE

Induction motors are widely used in various industries as drive motors for variety of machines. Due to its rugged construction, smoother and efficient operation, it has replaced dc motors in variety of applications. By reason of the important role played by synchronous machines (alternators and motors) in the electrical generation systems, the electrical technologistsalso need to be well versed in the construction and working of these machines. Further fractional horse power (FHP) machines are used in many control circuits of automation systems. Since technologists are expected to maintain industrial systems involving these machines it is highly essential to provide them necessary knowledge about construction and operation of these machines. This course therefore, aims to equip the students with the fundamental requirements of using these machines in different applications.

2. COMPETENCY

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

- **Use relevant Induction, Synchronous and FHP Machines for different electrical engineering applications.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a) Use the relevant three phase induction motor (IM) for different applications.
b) Use the relevant single phase induction motors in different applications.
c) Use the relevant three phase alternator for different load conditions.
d) Use suitable synchronous motors in different applications.
e) Use suitable Fractional HP motors for different applications.

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.

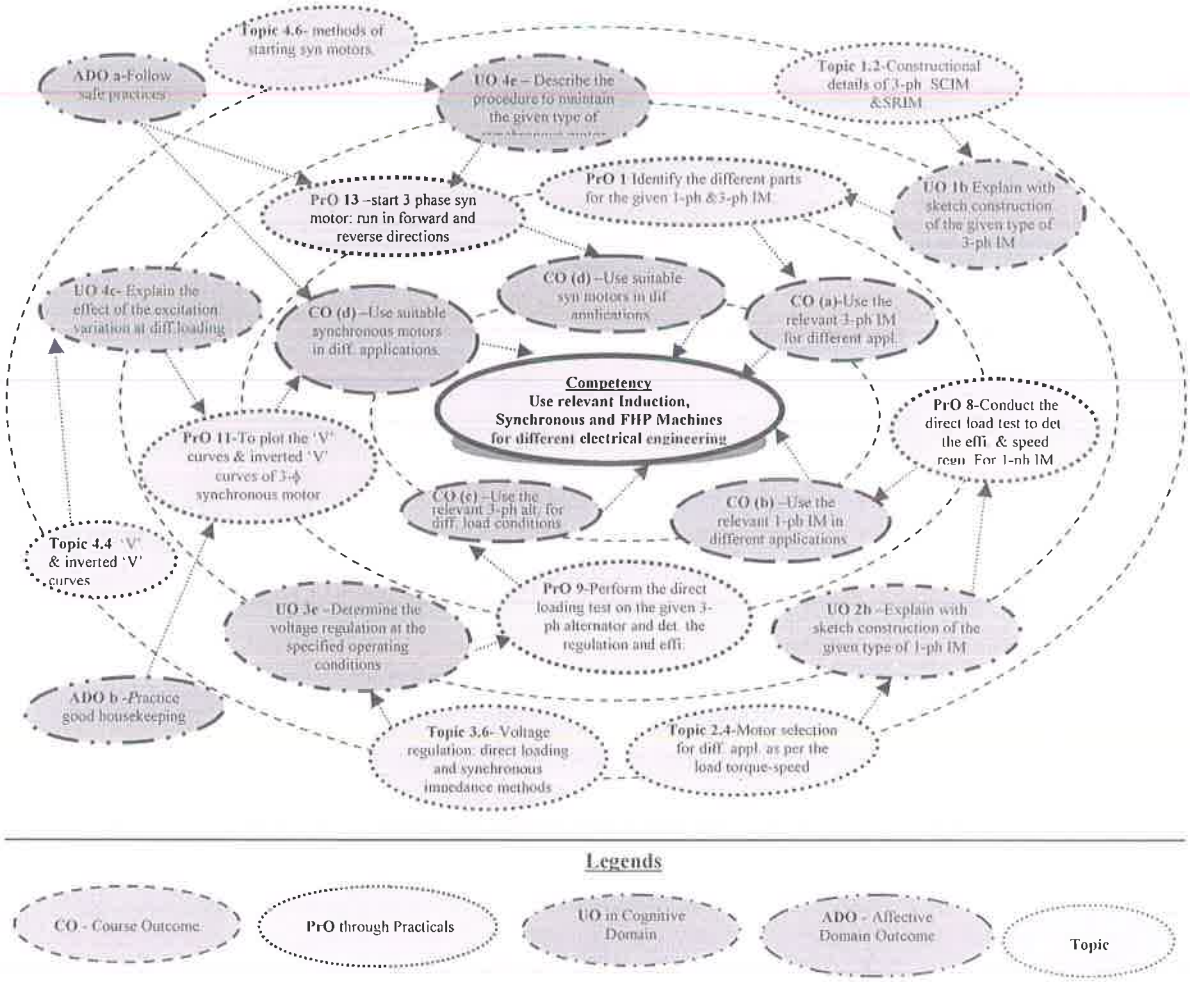

Figure 1 - Course Map

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 parts (along with function and materials) for the given single phase and three phase induction motor.	I/II	02*
2	Connect and run the three phase squirrel cage induction motors (in both directions) using the DOL, star-delta, auto-transformer starters (any two)	I	02*
3	Perform the direct load test on the three phase squirrel cage induction motor and plot the i) efficiency versus output, ii) power factor versus output, iii) power factor versus motor current and iv) torque – slip/speed characteristics.	I	02*
4	Conduct the No-load and Blocked-rotor tests on given 3-ϕ squirrel	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	cage induction motor and determine the equivalent circuit parameters.		
5	Conduct the No-load and Blocked-rotor tests on given 3-ϕ squirrel cage induction motor and plot the Circle diagram.	I	02*
6	Control the speed of the given three phase squirrel cage/slip ring induction motor using the applicable methods: i) auto-transformer, ii) VF.	I	02*
7	Control the speed of the given three phase slip ring induction motor using rotor resistance starter.	I	02*
8	Control the speed of the given three phase induction motor using pole changing methods	I	02#
9	Identify different windings & components of single phase capacitor start Induction Run motor & Connect to start & reverse the direction of rotation	II	02#
10	Conduct the direct load test to determine the efficiency and speed regulation for different loads on the given single phase induction motor; plot the efficiency and speed regulation curves with respect to the output power.	II	02*
11	Perform the direct loading test on the given three phase alternator and determine the regulation.	III	02*
12	Determine the regulation of the given three phase alternator from OC and SC tests (Synchronous impedance method)	III	02*
13	Start 3 phase synchronous motor & run synchronous motor in forward & reverse direction	IV	02*
14	Conduct the test on load or no load to plot the 'V' curves and inverted 'V' curves (at no-load) of 3-ϕ synchronous motor.	IV	02*
	Total		**28**

Minimum 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 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 %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working 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
- 'Organizing Level' in 2nd year
- 'Characterizing 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	Induction motors 3 hp/ 5hp, 415 V, 50 Hz, 1440 RPM squirrel cage type	1 to 6, 8
2	Induction motors 3 hp/ 5hp, 415 V, 50 Hz, 1440 RPM slip ring type.	1, 6, 7
3	Ammeters MI Type: AC/DC 0-5-10Amp	1 to 12, 14
4	Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V	1 to 12, 14
5	Wattmeter: Three phase double element 5/10Amp, 250/500V or sr no 6	1 to 12, 14
6	Wattmeter: Single phase, single element 2.5/5Amp, 200/400V,	1 to 12, 14
7	Low power factor wattmeter : Single phase, 2.5/5Amp, 250/500V	4, 5
8	Auto transformer: 3-phase, 5kVA, 0 to 500V.	2, 4, 5, 6.
9	Load bank: Resistive, 3-phase, 5kW, 415V	11
10	Load bank: inductive, 3-phase, 2 to 5kVAR, 415V	11
11	Load bank: capacitive, 3-phase, 2 to 5kVAR, 415V	11
12	Star- delta, auto transformers starters	2 to 6.
13	Clip on meter (amp, volts) digital/analog	All
14	Digital multimeter4 ½ digit with standard make for measurements	All
15	Tachometers: contact and non-contact types: 100 to 10000 RPM	all
16	Brake load or other suitable means to load motors with suitable measurement facilities of powers (mechanical).	3, 8
17	3 phase alternator: 5kVA, 415 V, 50 Hz, 4 pole, 1500 RPM.	9, 10
18	3 phase synchronous motor: 3hp, 415 V, 50 Hz, 1500 RPM.	11

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 Three Phase Induction Motor	1a. Explain with sketch working of the given three phase induction motor. 1b. Explain with sketch construction of the given type of three phase induction motor. 1c. Derive the expressions for rotor induced emf and torque of three phase induction motor for different operating conditions. 1d. Explain with sketch the operation of the motor in the specified quadrant. 1e. Determine the specified performance parameters of the motor. 1f. Explain with sketch the operation of the relevant starter for the given motor. 1g. Explain the specified method of speed control. 1h. Suggest the relevant IM for the specified different given applications.	1.1 Working principle: production of rotating magnetic field, Synchronous speed, rotor speed and slip. 1.2 Constructional details of 3 phase induction motors: Squirrel cage induction motor and Slip ring induction motor. 1.3 Rotor quantities: frequency, induced emf, power factor at starting and running condition. 1.4 Characteristics of torque versus slip (speed), Torques: starting, full load and maximum with relations among them. 1.5 Induction motor as a generalized transformer with phasor diagram. 1.6 Four quadrant operation, Power flow diagram 1.7 Starters: need and types; stator resistance, auto transformer, star delta, rotor resistance and soft starters. 1.8 Speed control methods: stator voltage, pole changing, rotor resistance and VVVF. 1.9 Motor selection for different applications as per the load torque-speed requirements. 1.10 Maintenance of three phase induction motors
Unit– II Single phase induction motors	2a. Explain with sketch working of the given single phase induction motor. 2b. Explain with sketch construction of the given type of single phase induction motor. 2c. Suggest the relevant single phase motor for the specified different applications. 2d. Describe the procedure to maintain given type of single phase induction motor.	2.1 Double field revolving theory, principle of making these motors self start. 2.2 Construction and working: Resistance start induction run, capacitor start induction run, capacitor start capacitor run, shaded pole, repulsion type, series motor, universal motor, hysteresis motor. 2.3 Torque-speed characteristics for all of the above motors. 2.4 Motor selection for different applications as per the load torque-speed requirements. 2.5 Maintenance of single phase induction motors
Unit-III Three phase alternators	3a. Explain with sketch working of the given type of alternator 3b. Explain with sketch construction of the given type	3.1. Principle of working, moving and stationary armatures. 3.2. Constructional details: parts and their functions, rotor constructions.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	of alternator. 3c. Compare the rotor constructions of the given types of alternators. 3d. Determine the voltage regulation at the specified operating conditions. 3e. Describe the procedure to maintain the given type f three phase alternators.	Windings: Single and Double layer. 3.3. E.M.F. equation of Alternator with numerical by considering short pitch factor and distribution factor. 3.4. Alternator loading: Factors affecting the terminal voltage of alternator; Armature resistance and leakage reactance drops. 3.5. Armature reaction at various power factors and synchronous impedance. 3.6. Voltage regulation: direct loading and synchronous impedance methods. 3.7. Maintenance of alternators
Unit –IV Synchronous motors	4a. Explain with sketch working of the given type of synchronous motor. 4b. Explain with sketch construction of the given type synchronous motor. 4c. Explain the effect of the excitation variation for the given loading conditions.. 4d. Suggest suitable synchronous motors for given applications. 4e. Describe the procedure to maintain the given type of synchronous motor	4.1 Principle of working /operation, significance of load angle. 4.2 Torques: starting torque, running torque, pull in torque, pull out torque. 4.3 Synchronous motor on load with constant excitation (numerical), effect of excitation at constant load (numerical). 4.4 V-Curves and Inverted V-Curves. 4.5 Hunting and Phase swinging. 4.6 Methods of Starting of Synchronous Motor. 4.7 Losses in synchronous motors and efficiency (no numericals). 4.8 Applications areas.
Unit-V Fractional horse power motors (FHP)	5a. Explain the working principle of the given FHP motor. 5b. Explain construction of the given type of FHP. 5c. Suggest relevant FHP motor for the specified application. 5d. Describe the procedure to maintain the given type of FHP motor	5.1.Construction and working: Synchronous Reluctance Motor, Switched Reluctance Motor, BLDC , Permanent Magnet Synchronous Motors, stepper motors, AC and DC servomotors. 5.2.Torque speed characteristics of above motors. 5.3. Applications of above motors.

Note:To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Three phase induction motors	18	02	08	10	20
II	Single phase induction motors	12	04	04	06	14

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
III	Three phase alternators	14	02	06	08	16
IV	Synchronous motors	12	02	04	06	12
V	Fractional horse power motors (FHP)	08	02	02	04	08
Total		**64**	**12**	**24**	**34**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess 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 information/product brochures on three phase induction motors.
b) Collect information/product brochures on single phase induction motors.
c) Collect information/product brochures on stepper motors.
d) Collect information/product brochures on AC servomotors.
e) Collect information/product brochures on DC servomotors.
f) Collect information/product brochures on synchronous motors.
g) Collect information/product brochures on different types of alternators.
h) Collect information/product brochures on AC servomotors.
i) Collect information in brochures or other means for setting up VVVF drives.
j) Determine the full load torque form the name plate specifications of induction motors in the laboratory or other places.

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 Elevatos.
g) Pre-guided visits to, railway stations and Elevator manufacturing componay toobserve 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 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. **Induction motors:** Prepare report on market survey of various single and three phase induction motors(specification, manufacturer, cost, area of use)
b. **Synchronous motors:** Prepare report market survey of various synchronous motors(specification, manufacturer, cost, area of use)
c. **Alternators:** Prepare report market survey of various synchronous generators (specification, manufacturer, cost, area of use)
d. **FHP motors:** Prepare report on market survey of various special purpose FHP motors(specification, manufacturer, cost, area of use)

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	A text book of Electrical technology Vol II	Theraja B. L. Theraja A. K.	S. Chand and Co. New Delhi ISBN 10: 8121924375
2	Electrical Machines	Bhattacharya S. K.	Tata McGraw Hill, New Delhi ISBN 9780075415396
3	Electrical Machines	Kothari D. P. and Nagrath I. J.	McGraw Hill, New Delhi ISBN13: 978-9352606405
4	Basic Electrical Engineering	Mittle V. N.	McGraw Hill, New Delhi, 2014 ISBN 9780074516324
5	Special Purpose Electrical Machines	Sen S. K.	Khanna Publishers, New Delhi, ISBN- 9788174091529
6	Special Electrical Machines	Janardanan E. G	Prentice Hall India, New Delhi ISBN: 9788120348806
7	Electrical Technology	Hughes E.	ELBS
8	Electrical Technology	Cotton H.	ELBS

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) www.nptel.iitm.ac.in
b) www.howstuffworks.com/
c) www.vlab.com
d) www.khanacademy.com
e) https://freevideolectures.com/course/2335/basic-electrical-technology/35
f) https://freevideolectures.com/course/2335/basic-electrical-technology/36

g) https://freevideolectures.com/course/2335/basic-electrical-technology/37
h) https://freevideolectures.com/course/2335/basic-electrical-technology/38
i) https://freevideolectures.com/course/2335/basic-electrical-technology/39
j) https://www.youtube.com/watch?v=fYV_siCu_RI
k) https://www.explainthatstuff.com/how-stepper-motors-work.html
l) https://www.edn.com/design/sensors/4406682/Brushless-DC-Motors---Part-I--Construction-and-Operating-Principles
m) https://www.youtube.com/watch?v=bCEiOnuODac


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

Program Name : Electrical Engineering Program Group

Program Code : EE/EP/EU

Semester : Fifth

Course Title : Switchgear and Protection

Course Code : 22524

1. RATIONALE

In spite of all care and precautions taken in the design, installation and operation of Power system and power equipment, abnormal conditions and faults do occur in the system. Some fault such as short circuits can prove highly damaging, not only to the components but also to the entire power system. However continuity of power supply is needed in day to day life.So study of switchgears and protection schemes is essential. It is expected that the understanding of operational principles, selection and testing aspects of switchgear and protection system must be known by students which ultimately help them to maintain the reliability of electric supply while performing their duties as a supervisor or a technician in substation, manufacturing industries and public service utilities.

2. COMPETENCY

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

- **Maintain switchgear and protection schemes used in electrical power 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. Identify various types of faults in power system.
b. Select suitable switchgears for different applications.
c. Test the performance of different protective relays.
d. Maintain protection systems of alternators and transformers.
e. Maintain protection schemes for motors and transmission lines.
f. Maintain protection schemes for power system against over voltages.

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
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.

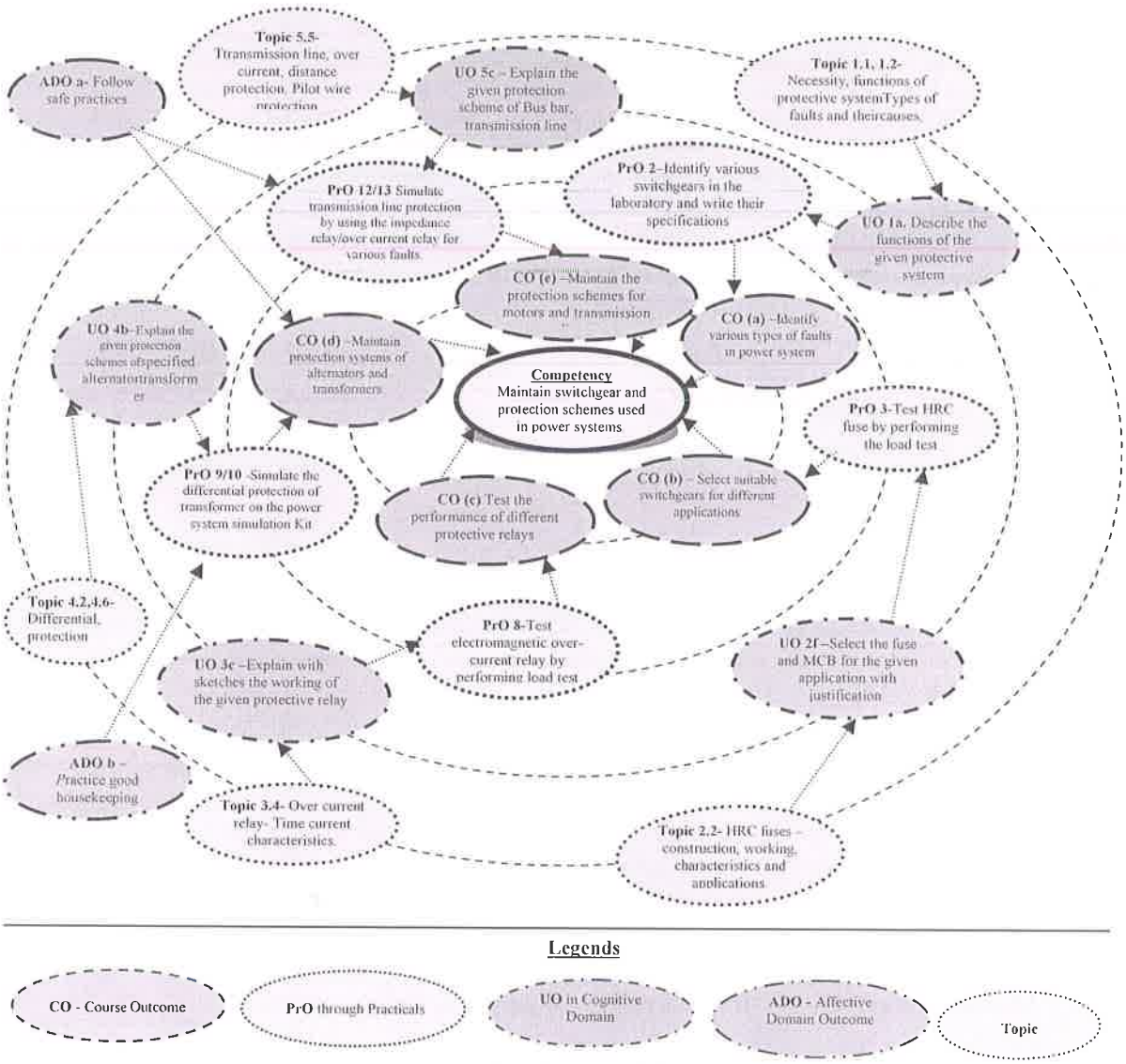

Figure 1 - Course Map

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	Use switchgear testing kits.	I	02*
2	Identify various switchgears in the laboratory and write their specifications.	I	02*
3	Test HRC fuse by performing the load test.	II	02*
4	Test MCB by performing the load test	II	02*
5	Dismantle MCCB/ELCB and identify various parts.	II	02*
6	Video show on /Dismantle ACB/VCB and identify different parts.	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Carry out plug and time setting (with PSM, TSM) of induction type electromagnetic relay.	III	02*
8	Test electromagnetic over-current relay by performing load test.	III	02*
9	Simulate differential protection scheme forO/	IV	02*
10	Simulate differential protection scheme for transformer on the power system simulation Kit. Part- II	IV	02
11	Test the working of the single phasing preventer using a three phase induction motor.	V	02*
12	Simulate transmission line protection by using the impedance relay/over current relay for various faults. (On transmission line protection simulation Kit). Part- I	V	02
13	Simulate transmission line protection by using the impedance relay/over current relay for various faults. (On transmission line protection simulation Kit). Part- II	V	02
14	Video show on/Dismantle Thyrite type arrester and identify different parts.	VI	02*
15	Video show on/Perform neutral earthing at different substations / locations. Part- I	VI	02*
16	Video show on/Perform neutral earthing at different substations / locations. Part- II	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 %
a.	Preparation of experimental set up	20
b.	Setting, collection of data and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.

e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'CharacterisingLevel' 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	Switchgear testing kit–(0-500V),(1-100A), variable AC and DC, with timer	1, 3,4
2	Cut sections and charts of MCB, MCCB, ELCB, HRC Fuse, ACB, Contactors and Induction type Over current/Earth fault, Microprocessor, Numerical relays.	2
3	HRC Fuses:5A, 10A, 16A, 32A, 100A.	3
4	MCB (SP/SPN/TP/TPN): 5A, 10A, 16A, 20A	4
5	MCCB: 32A, 63A.	5
6	ACB or VCB: 200A.	6
7	Over-current Induction type electromagnetic relay: 10A	7,8
8	Transformer protection simulation Kit.	9,10
9	Three phase induction motor with Single phasing preventer: 3HP.	11
10	Transmission line protection simulation Kit.	12,13
11	Thyrite type Lightning arrester.	14
12	Earth tester 500 V, hand driven or digital type.	15, 16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Basics of protection	1a. Describe the functions of elements of the given protective system. 1b. Explain with sketches the given types of faults and abnormalities in a power system. 1c. Explain with sketches the concept of the Backup protection for the given protection zone. 1d. Calculate the short circuit	1.1 Necessity, functions of protective system. 1.2 Normal and abnormal conditions. 1.3 Types of faults and their causes. 1.4 Protection zones and backup protection 1.5 Short circuit fault calculations in lines fed by generators through transformers 1.6 Need of current limiting reactors and their arrangements.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	currents of symmetrical faults. 1e. Select suitable current limiting reactors for the given situation with justification.	
Unit– II Circuit Interrupti on Devices	2a. Explain with sketches the operation of given isolators. 2b. Explain with sketches the given terms related to the specified fuse (s). 2c. Explain with sketches arc formation, high resistance and zero current interruption in the given type of circuit breaker. 2d. Explain with sketches the operation of the given circuit breaker(s). 2e. Compare the given circuit interrupting devices on the specified parameters. 2f. Select the relevant fuse and MCB for the given application with justification. 2g. Select the relevant circuit breaker and MCCB for the given application with justification. 2h. Explain the Insulation coordination for the given installation/machine.	2.1 Isolators- Vertical break, Horizontal break and Pantograph type. 2.2 HRC fuses – Construction, working, characteristics and applications. 2.3 Arc formation process, methods of arc extinction (High resistance and Low resistance). 2.4 Arc voltage, Recovery voltage, Re-striking voltage, RRRV. 2.5 HT circuit breakers (Sulphur-hexa Fluoride (SF6), Vacuum circuit breaker) - Working, construction, specifications and applications. 2.6 L.T. circuit breaker(Air circuit breakers (ACB), Miniature circuit breakers (MCB), Moulded case circuit breakers (MCCB), MPCB , RCBO and Earth leakage circuit breaker(ELCB)) - Working and applications. 2.7 Selection of LT and HT circuit breakers (ratings). 2.8 Selection of MCCB for motors. 2.9 Gas insulated switchgear. 2.10 Insulation Coordination : Type1 & Type2 coordination 2.11 Introduction to ETAB
Unit-III Protective Relays	3a. Explain the given terms related to protective relays. 3b. Explain need of the given type of relay in power system. 3c. Explain with sketches the working of the given protective relay. 3d. Select relevant protective relay for required application with justification. 3e. Explain the steps for the specified settings of the given relay.	3.1 Fundamental quality requirements: Selectivity, Speed, Sensitivity, Reliability, Simplicity, Economy. 3.2 Basic relay terminology- Protective relay, Relay time, Pick up, Reset current, current setting, Plug setting multiplier, Time setting multiplier. 3.3 Protective relays: Electromagnetic disc relay operation, Thermal relay. Block diagram and working of Static relay, over voltage relay. 3.4 Over current relay-Time current characteristics. 3.5 Microprocessor based protection relays: Block diagram, workingand protection features. 3.6 Distance relaying- Principle

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		3.7 Directional relay: Need and operation with block diagram. 3.8 Operation of current and voltage differential relay.
Unit –IV Protection of Alternator and Transformer	4a. Describe the causes and remedies of the given faults in the specified machine. 4b. Explain with sketches the given protection schemes of the specified machine. 4c. Calculate CT ratio of the specified transformer protection scheme. 4d. Calculate percentage of winding protected for the specified alternator.	**Alternator Protection** 4.1 Faults 4.2 Differential protection : over current, earth fault, overheating and field failure protection. 4.3 Reverse power protection. **Transformer Protection** 4.4 Faults. 4.5 Differential, over current, earth fault, over heating protection. 4.6 Limitations of differential protection. 4.7 Buchholz relay: Construction, operation, merits and demerits. 4.8 Introduction to Microprocessor based transformer protection.
Unit-V Protection of Motors, Bus-bar And Transmission Line	5a. Describe the causes and remedies of the given faults in specified equipment. 5b. Explain with sketches the given protection scheme of the specified motor. 5c. Explain with sketches the given protection scheme of given component of the power system.	**Motor** 5.1 Faults. 5.2 Short circuit protection, Overload protection, Single phase preventer. **Bus bar and Transmission line** 5.3 Faults on Bus bar and Transmission Lines. 5.4 Bus bar protection: Differential and Fault bus protection. 5.5 Transmission line: Over current, Distance and Pilot wire protection. 5.6

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Protection.	08	04	04	02	10
II	Circuit Interrupting Devices.	16	04	06	06	16
III	Protective Relays.	16	04	06	06	16
IV	Protection of Alternator and Transformer.	16	04	06	06	16
V	Protection of Motor, Busbar and Transmission Line.	08	02	04	06	12
Total		**64**	**18**	**26**	**26**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a) Collect specifications of different switchgear equipment used in electrical power system through market survey/visit and write a technical report.
b) Visit 400/220/132/66/33kV substation and take the help of sub-station in-charge to understand various switchgears, protective schemes and occurrences of faults.
c) Collect data of different protective schemes used for alternator, transformer, bus bar and transmission lines through internet/ industrial visit.
d) Write all the safety precautions which are to be taken while working with different switchgears and protective schemes.
e) Collect data of Lightning arresters used for substation through internet/ industrial visit.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c) About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d) With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e) Guide student(s) in undertaking micro-projects.
f) Correlate subtopics with power system protection and electrical equipments.
g) Use proper equivalent analogy to explain different concepts.
h) Use Flash/Animations to explain various Switchgears and protection schemes.
i) Use open source MATLAB models to explain different concepts of protective schemes.

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

a) **Installation and commissioning of MCB:**Calculate load current anddecide specifications of MCBsrequired for a load circuit of 5 kW or more and install it.
b) **Case study of past major grid power failure:**Prepare a report after surveying in the power failure or present the findings.
c) **Installation and commissioning of ELCB:** Calculate load current and decide specifications of ELCB required for a residential load circuit upto 5 kW and install it.
d) **Alternator/Transformer protection schemes:**Prepare power point presentation on Alternator/Transformer protection schemes used in generating station/substations.
e) **Motor protection schemes:** Prepare the detailed protection schemes for the 20HP motor.

13. SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1	Principles of Power System	Mehta V. K ; Rohit Mehta .	S.Chand and Co., New Delhi., 2016 ISBN: 978-81-2192-496-2.
2	Switchgear and Protection	Rao.Sunil S.	Khanna Publishers, New Delhi, 2015 ISBN: 978-81-7409-232-3.
3	Switchgear and Power System Protection	Singh, R. P.	PHI Learning, New Delhi,2015 ISBN: 978-81-203-3660-5.
4	Switchgear and Protection	Gupta. J. B.	S. K. Kataria and Sons, New Delhi, 2015ISBN: 978-93-5014-372-8.
5	Switchgear and Protection	Veerapan, N., Krishnamurty, S. R.	S .Chand and Co., New Delhi. 2014 ISBN: 978-81-2193-212-7.
6	Power System Protection and Switchgear	Ram, Badri Vishwakarma D. N.	McGraw-Hill, New Delhi. 2015 ISBN : 978-07-107774-X

14. SOFTWARE/LEARNING WEBSITES

a. www.cgglobal.com
b. www.youtube.com /switchgears
c. www.dreamtechpress.com /eBooks
d. www.nptelvideos.in/electrical engineering/ relays
e. www.electrical4u.com
f. www.en.wikipedia.org
g. www.abb.co.in/ProductGuide/
h. https://play.google.com/store/apps/

Program Name : **Electrical Engineering Program Group**

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

Semester : **Fifth**

Course Title : **Energy Conservation and Audit**

Course Code : **22525**

1. RATIONALE

The pressure of Technological development in all sectors on the Renewable energy sources has led to the growingthe cost of energy around the world. Efficient and judicious use of the available energy sources would lead to the easing of such pressures and drastic decrease in the operating costs of the organizations and industries. Thus it is necessary to save and conserve energy to the maximum possible extent. Also essential theoretical knowledge and practical skills about the concept of energy conservation is to be provided through different approaches, project management and economics accepts. The process of energy audit will help to identify the various possible avenues in which savings of energy can be effectively adopted. This course makes the diploma holder well acquainted in the techniques of energy conservation in the fields of engineering. It also introduces him to the energy audit procedures.

2. COMPETENCY

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

- **Undertake energy conservation and energy audit.**

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 energy conservation policies in India.
b. Implement energy conservation techniques in electrical machines.
c. Apply energy conservation techniques in electrical installations.
d. Use Co-generation and relevant tariff for reducing losses in facilities.
e. Carryout energy audit for electrical system.

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*

1. 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.

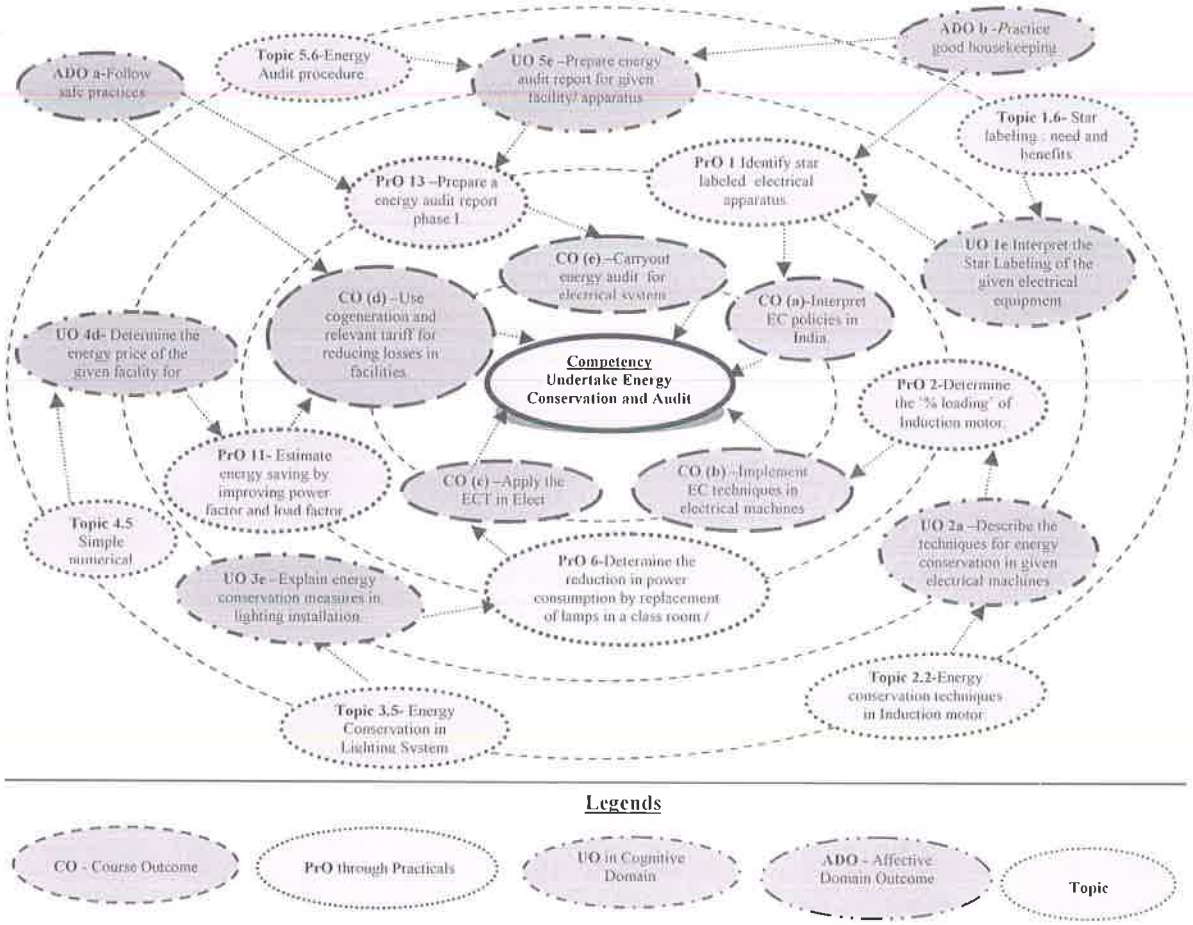

Figure 1 - Course Map

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 star labeled electrical apparatus andcompare the data for various star ratings.	I	02*
2	Determine the '% loading' along with the related efficiency for different loads of given Induction motor (30 to 110 percent in steps of 10%).	II	02*
3	Determine the reduction in power consumption in star mode operation of Induction motor compared to delta mode.	II	02*
4	Use APFC unit for improvement of p. f. of electrical load.	II	02
5	Compare power consumption of different types of TL with choke, electronic ballast and LED lamps by direct measurements.	III	02
6	Determine the reduction in power consumption by replacement of lamps in a class room / laboratory.	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Determine the reduction in power consumption by replacement of Fans and regulators in a class room / laboratory.	III	02*
8	Collect electricity bill of an industrial consumer and suggest suitable tariff for energy conservation and its impact on energy bill.	IV	02
9	Collect electricity bill of a commercial consumer and suggest suitable tariff for conservation and reduction of its energy bill.	IV	02*
10	Collect electricity bill of a residential consumer and suggest suitable means for conservation and reduction of the energy bill.	IV	02*
11	Estimate energy saving by improving power factor and load factor for given cases.	IV	02
12	Prepare a sample energy audit questionnaire for thegiven industrial facility.	V	02*
13	Prepare an energy audit report (phase-I)	V	02*
14	Prepare an energy audit report (phase-II)	V	02*
15	Prepare an energy audit report (phase-III)	V	02*
	Total		**30**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. 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
- 'Organizing Level' in 2nd year
- 'Characterizing 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	Pr O. No.
1	Induction motor (3phase /1 phase)	2,3
2	Ammeters MI Type: AC/ DC 0-5-10Amp	2,3
3	Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V	2,3
4	Wattmeter: Three phase double element 5/10Amp, 250/500V	2,3
5	Wattmeter: Single phase, single element 2.5/5Amp, 200/400V,	5,6,7
6	Low power factor wattmeter : Single phase, 5/10Amp, 250/500V	4
7	Three phase Power factor meters: AC, 415V, 50 Hz , 5-10 Amp	1
8	Load bank: Resistive, 3-phase, 5kW, 415V	4
9	Automatic power factor controller (APFC)	4
10	Star- delta convertor	3
11	Lux meter	13,14
12	Clip on meter (amp, volts) digital/analog	5,13,14
13	FTL,CFL,LED of different ratings	5
14	Electric choke, Electronic ballast	5
15	Electric regulators ,Electronic regulators	7

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 Energy Conservation Basics	1a. Interpret the given energy conservation clause(s) 1b. Explain the specified BEE role(s) 1c. Explain the specified MEDA role(s) 1d. Interpret the Star Labeling of the given electrical equipment	1.1 Energy Scenario: Primary and Secondary Energy, Energy demand and supply, National scenario. 1.2 Energy conservation and Energy audit; concepts and difference 1.3 Energy Conservation Act 2001; relevant clauses of energy conservation 1.4 BEE and its Roles 1.5 MEDA and its Roles 1.6 Star Labeling: Need and its benefits.
Unit– II Energy Conservation in	2a. Describe the techniques forenergy conservation in the given electrical machine.	2.1 Need for energy conservation in induction motor and transformer. 2.2 Energy conservation techniques in induction motor by:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Electrical Machines	2b. Explain with sketches the working principle of the given energy conservation equipment. 2c. Select relevant energy conservation equipment for given electrical machine with justification. 2d. Describe the technique(s) to improve the performance efficiency of the given type of electrical machine(s). 2e. Describe with sketches the construction and applications of the specified energy efficient transformer.	a) Improving Power quality. b) Motor survey c) Matching motor with loading. d) Minimizing the idle and redundant running of motor. e) Operating in star mode. f) Rewinding of motor. g) Replacement by energy efficient motor i) Periodic maintenance 2.3 Energy conservation techniques in Transformer. a) Loading sharing b) Parallel operation c) Isolating techniques d) Replacement by energy efficient transformers e) Periodic maintenance 2.4 Energy Conservation Equipment : Soft starters, Automatic star delta convertor, Variable Frequency Drives, Automatic p. f. controller (APFC) , Intelligent p. f. controller (IPFC), Active Harmonic filters (AHF). 2.5 Energy efficient motor; significant features, advantages, applications and limitations. 2.6 Energy efficient transformers, amorphous transformers; epoxy Resin cast transformer / Dry type of transformer.
Unit-III Energy conservation in Electrical Installation systems	3a. Interpret losses in the given Power system 3b. Explain the method to reduce the specifiedtechnical loss in the given electrical installation. 3c. Explain the method to reduce the specified commercial loss in the given electrical installation. 3d. Select the relevant energy conservation equipment for the given system with justification. 3e. Explain energy conservation measures for the specified lighting installation.	3.1 Aggregated Technical and commercial losses (ATC); Power system at state, regional, national and global level. 3.2 Technical losses; causes and measures to reduce by. a) Controlling I^2R losses. b) optimizing distribution voltage c) balancing phase currents d) compensating reactive power flow 3.3 Commercial losses: pilferage, causes and remedies 3.4 Energy conservation equipments: Maximum Demand Controller , kVAR Controller, Automatic Power Factor controller(APFC) 3.5 Energy Conservation in Lighting System a) Replacing Lamp sources. b) Using energy efficient luminaries. c) Using light controlled gears. d) Installation of separate transformer/ servo stabilizer for lighting.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		e) Periodic survey and adequate maintenance programs. 3.6 Energy Conservation techniques in fans, Electronic regulators.
Unit –IV Energy conservation through Cogeneration and Tariff	4a. Describe the method (s) to minimize losses in the given electrical system. 4b. Explain the method for optimum use of energy source in the given facility. 4c. Identify the cogeneration system for the given facility. 4d. Determine the energy price of the given facility for energy saving.	4.1 Co-generation and Tariff; concept, significance for energy conservation **4.2 Co-generation** a) Types of cogeneration on basis of sequence of energy use (Topping cycle, Bottoming cycle) b) Types of cogeneration basis of technology (Steam turbine cogeneration, Gas turbine cogeneration, Reciprocating engine cogeneration). c) Factors governing the selection of cogeneration system. d) Advantages of cogeneration. **4.3 Tariff** a) Types of tariff structure: LT and HT, Special tariffs; Time-off-day tariff, Peak-off-day tariff, Power factor tariff, Maximum Demand tariff, Load factor tariff and Availability Based Tariff (ABT). 4.4 Application of tariff system to reduce energy bill.
Unit-V Energy Audit of electrical systems	5a. Suggest relevant instrument (s) for the specified energy audit with justification. 5b. Develop questionnaire for the energy audit of the given facility. 5c. Develop the energy flow diagram of the given facility/ apparatus. 5d. Calculate the 'Simple Pay Back period' for the given situation. 5e. Prepare the energy audit report for the given facility/ apparatus	5.1 Energy audit (definition as per Energy Conservation act), Specific energy consumption. 5.2 Energy audit instruments and their use. 5.3 Questionnaire for energy audit projects. 5.4 Energy flow diagram (Sankey diagram) 5.5 Simple payback period, Energy Audit procedure (walk through audit and detailed audit). 5.6 Energy Audit report format.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Energy Conservation Basics	02	02	02	04	08
II	Energy Conservation in Electrical Machines	12	02	04	08	14
III	Energy conservation in Electrical Installation system	12	00	08	08	16
IV	Energy conservation through Cogeneration and Tariff	11	04	04	08	16
V	Energy Auditof electrical systems	11	04	04	08	16
Total		**48**	**12**	**22**	**36**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct 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) Carry out internet survey (BEE/MEDAwebsite) to collect information related Energy conservation projects.
b) Collect the catalogues of star labeled equipments (min.2)
c) Write report on performance of motor after rewinding.
d) Collect videos to demonstrate working of Energy Conservation Equipments(any 2)
e) Prepare PPT presentation on energy efficient motors.
f) Prepare PPT presentation on energy efficient transformers.
g) Collect information about energy efficient luminaries.
h) Collect videos to demonstrate working of Energy Audit instruments.
i) Visit a facility adopting cogeneration systemand prepare a presentation.

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 Energy Conservation techniques and equipment.
g) Pre-guided visits to malls, railway stations and areas adopting conservation strategies in which the students will casually observe during their visits.

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

a) **Energy efficient lamps:**Prepare comparative charts with ratings, cost and manufacturer details.
b) **Energy conservation campaign:** Prepare charts/slogans to create energy conservation awareness in polytechnic.
c) **Energy efficient electrical machines**: Prepare technical presentation on details of energy efficient transformers / motors.
d) **Energy conservation policies**: Prepare report on energy conservation policies of Govt. Maharashtra 2017.
e) **Energy Manager and Energy Auditor**: Identify from available resources their roles and responsibilities.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Guide Books no. 1 to 4 for National Certification Examination for Energy Managers and Energy Auditors	Bureau of Energy Efficiency (BEE)	Bureau of Energy Efficiency (A Statutory body under Ministry of Power, Government of India) (Fourth Edition 2015)
2	India - The Energy Sector	Henderson, P. D.	University Press, Delhi, 2016 ISBN: 978-0195606539
3	Energy Management Handbook	Turner, W. C.	Fairmount Press, 2012 ISBN 9781304520708
4	Energy Management and Conservation	Sharma, K. V., Venkataseshaiah; P.	I K International Publishing House Pvt. Ltd; 2011 ISBN 9789381141298
5	Principles of Power System	Mehta ,V. K.	S. Chand &Co.New Delhi, 2016, ISBN 9788121905947

S. No.	Title of Book	Author	Publication
6	Energy Management	Singh, Sanjeey; Rathire, Unmesh	S K Kataria&sons,New Delhi ISBN-13: 9789350141014.
7	Efficient Use and Management of Electricity in Industry	Desai, B. G.; Rana, J. S.; A. Dinesh, V.;Paraman, R.	Devki Energy Consultancy Pvt. Ltd.
8	Energy Engineering And Management	Chakrabarti, Amlan	e-books Kindle Edition
9	Energy Management	Murphy W.R.	Butterworth-Heinemann Publication
10	Art of reading Electricity bills	TalwareYogendra	DnyatavyaPrakashan

14. SOFTWARE/LEARNING WEBSITES

a) Website of bureau of energy and efficiency : www.bee-india.nic.in
b) Website of AkshayUrja News Bulletin : www.mnes.nic.in
c) Notes on energy management on : www.energymanagertraining.com
d) www.greenbusiness.com
e) www.worldenergy.org
f) Maharashtra Energy Development Agency (MEDA):www.mahaurja.com
g) Notes on energy management on: www.energymanagertraining.com
h) www.greenbusiness.com
i) www.worldenergy.org


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