Maharashtra State Board of Technical Education, Mumbai

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

Program Name : Diploma in Electrical Engineering

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

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

Semester : Fifth **Scheme : I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme												Grand Total
								Theory						Practical						
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total	
				L	T	P			Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Management	MAN	22509	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
2	Industrial AC Machines	IAM	22523	4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
3	Switchgear and Protection	SAP	22524	4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
4	Energy Conservation and Audit	ECA	22525	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
	Elective (Any One)																				
5	Elements of Industrial Automation	EIA	22526	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Power Electronics Application	PEA	22527	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Wind Power Technologies	WPT	22528	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Power System Analysis	PSA	22529	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Illumination and Electrification of Buildings	IEB	22530	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
6	Enterprenureship Development	EDE	22032	2	-	2	4	--	--	--	--	--	--	--	50@	20	50~	20	100	40	100
7	Industrial Training	ITR	22057	-	-	6	6	--	--	--	--	--	--	--	75#	30	75	30	150	60	150
8	Capstone Project Planning	CPP	22058	-	-	2	2	--	--	--	--	--	--	--	25@	10	25	10	50	20	50
			Total	**19**	**-**	**18**	**37**	--	**350**	--	**150**	--	**500**	--	**250**	--	**250**	--	**500**	--	**1000**

Student Contact Hours Per Week: **37 Hrs.** Medium of Instruction: **English**
Theory and practical periods of 60 minutes each. Total Marks : **1000**
Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical
@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment
* Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain LOs required for the attainment of the COs.
~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**
- **Evalution of Industrial Training and its reports is to done after completion of Industrial Training. Credits of Industrial Training will not affect the framing of time table.**

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; Cr-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.

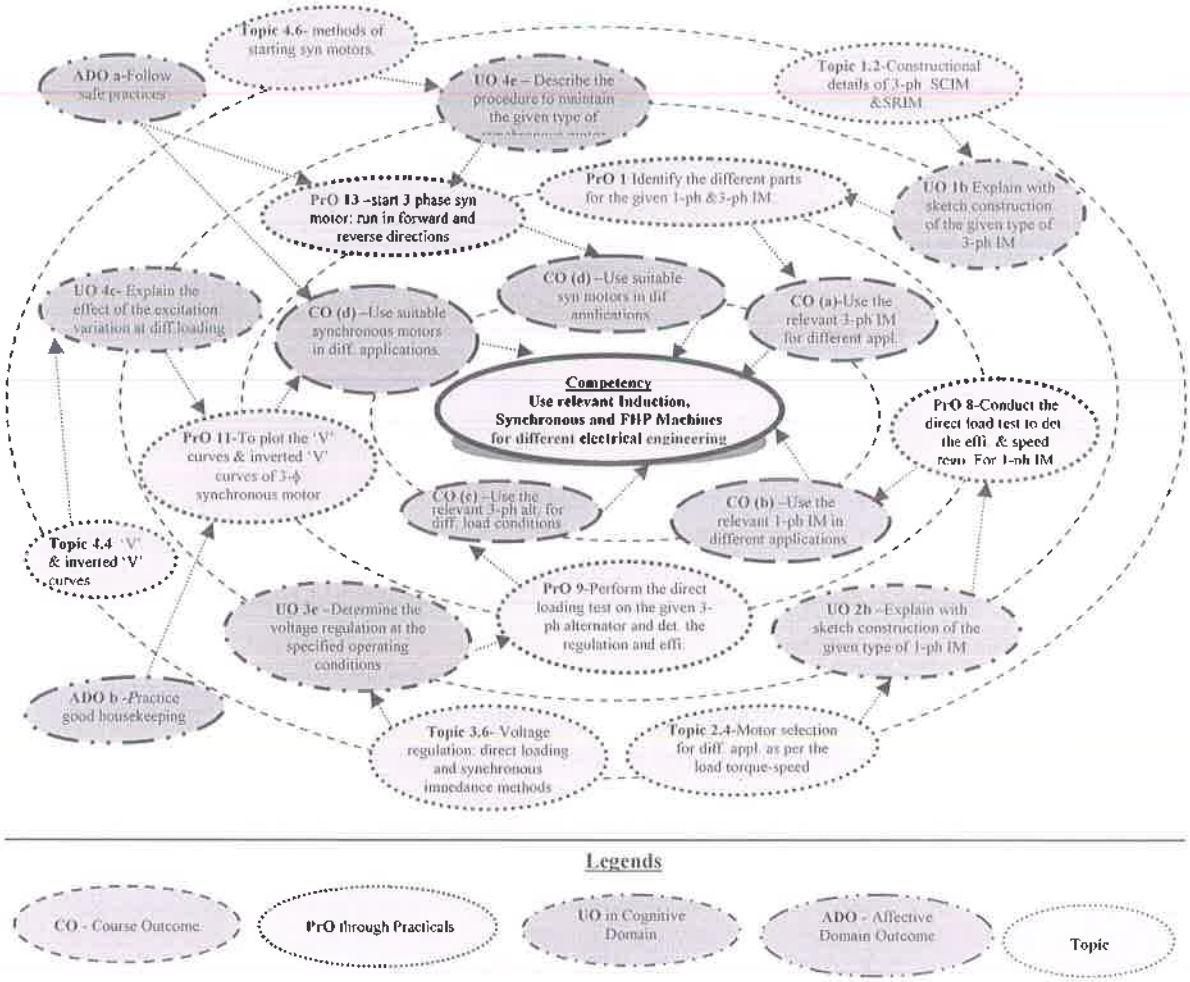

Figure 1 - Course Map

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	ESE		PA		Total		ESE		PA		Total	
L	T	P		Hrs.	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.

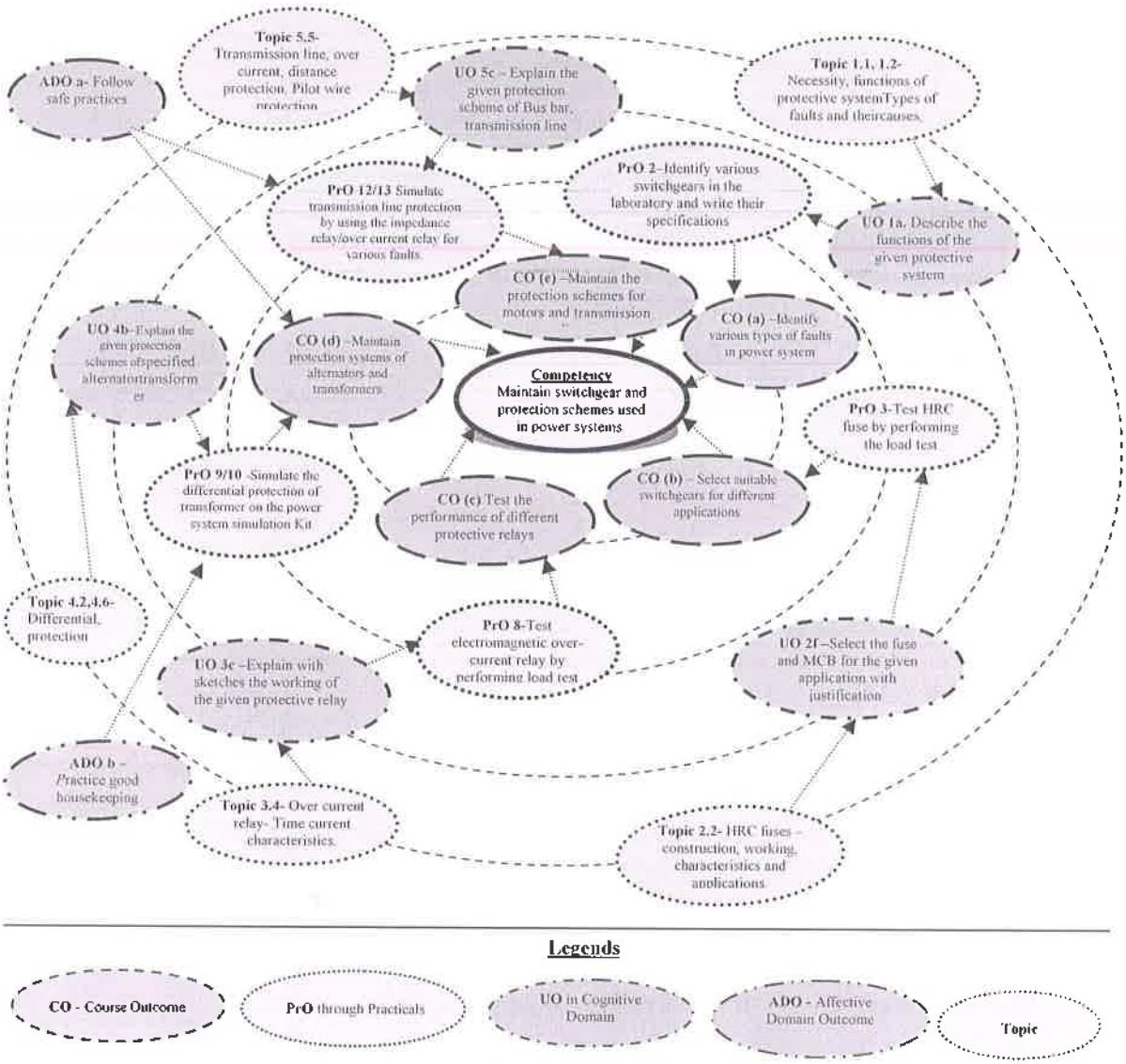

Figure 1 - Course Map

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.

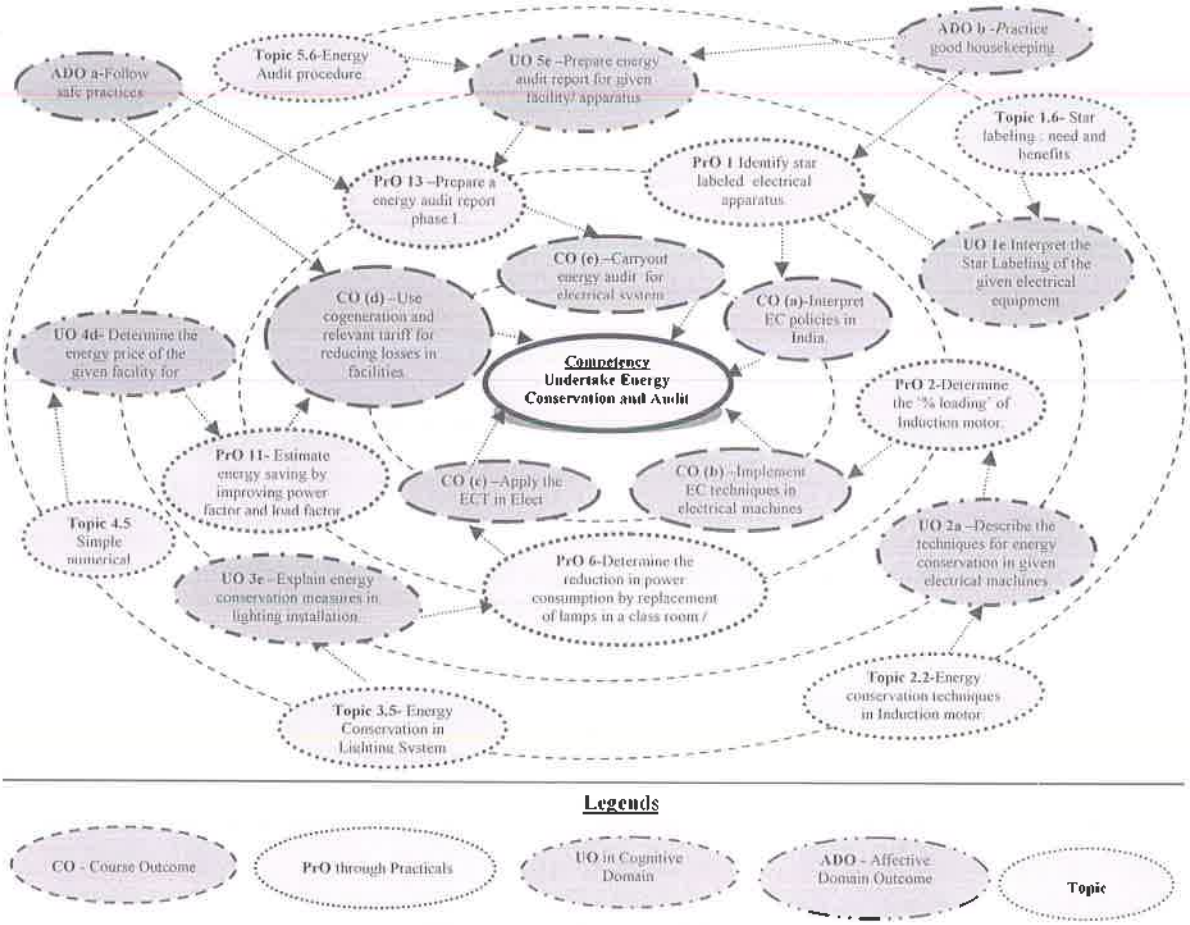

Figure 1 - Course Map

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 978812190594?

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

Program Name : **Electrical Engineering Program Group**

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

Semester : **Fifth**

Course Title : **Elements of Industrial Automation (Elective)**

Course Code : **22526**

1. RATIONALE

This course aims to acquaint students with vital components of automation such as motor control circuits, typical input/output devices, Programmable Logic Controller (PLC), Distributed Control System (DCS), Supervisory Control and Data Acquisition (SCADA) and Human Machine Interface (HMI). This will facilitate students to develop understanding and skills related with operation and maintenance of basic building blocks of industrial automation, which will in turn enable them to effectively upkeep the automated systems in industry.

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 PLC related automation systems.**

3. COURSE OUTCOMES (COs)

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

a. Maintain the relevant input/output components in industrial control circuits.
b. Wire PLCs for different applications.
c. Troubleshoot the PLC ladder programs for simple applications.
d. Test the PLC program in different applications.
e. Maintain the DCS and SCADA for different applications

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

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

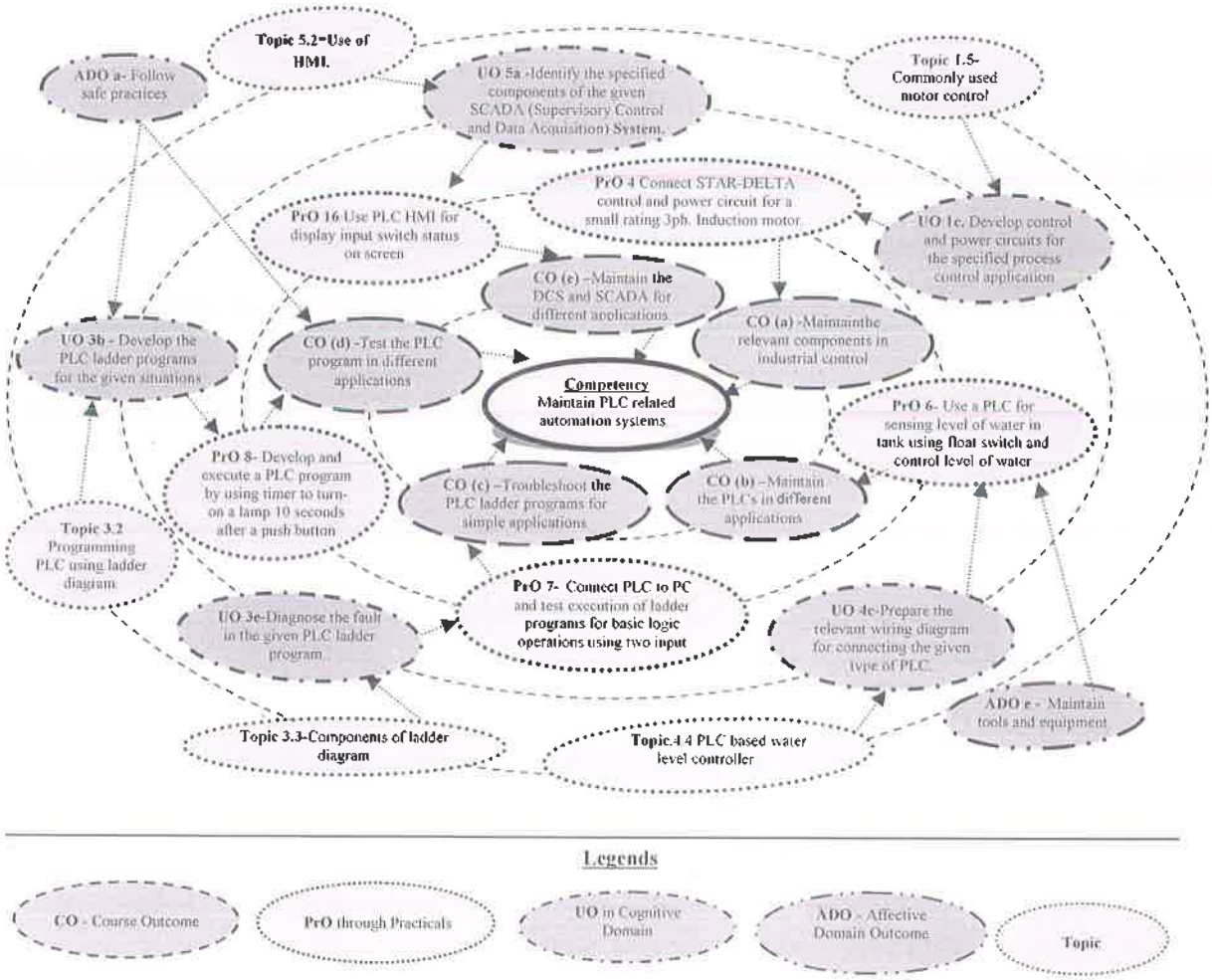

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify symbols in industrial control diagrams.	I	02*
2	Connect DOL starter control and power circuit for small rating 3ph Induction motor.	I	02*
3	Connect FOR-STOP-REV control and power circuit for a small rating 3ph Induction motor.	I	02*
4	Connect STAR-DELTA control and power circuit for a small rating 3ph. Induction motor.	I	02*
5	Simulate a simple seal-in circuit using PLC simulator.	III	02*
6	Connect PLC to PC and test execution of ladder programs for basic logic operations using two input switches and one output indicating lamp.	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Execute a PLC program by using timer to turn-on a lamp 10 seconds after a push button press.	III	02*
8	Execute the PLC program by to count number of push button press events and display the same on screen.	III	02*
9	Connect PLC for STAR-DELTA staring of 3ph. Induction motor and test the ladder program for the same.	III	02
10	Connect PLC for FOR-STOP-REV control of 3ph. Induction motor and test the ladder program for the same.	III	02*
11	Use the PLC for running a stepper motor in clock-wise/anti-clock wise direction.	IV	02*
12	Use the PLC for sensing level of water in tank using float switch and control level of water using ON/OFF solenoid valve.	IV	02*
13	Use PLC for ON/OFF temperature control.	V	02
14	Use PLC for simulating traffic light control.	V	02
15	Use PLC HMI for display input switch status on screen.	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.	Programming PLC and diagnose fault in the same.	30
c.	Observations and Recording	05
d.	Interpretation of result and Conclusion	05
e.	Answer to sample questions	20
f.	Submission of report in time	10
g.	Safety measures	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	Control components: Push buttons (5 NOS), indicating lamps (5 NOS), float switch (2 NOs)	2 to 16
2	Three phase AC contactors (2 NOS)	2 to 16
3	Small rating (< 1HP) three phase Induction motor.	2 to 16
4	PLC with min 8 I/Os and HMI and its simulation/programming software.(1 No.)	2 to 16
5	Stepper motor drive module.	2 to 16
6	Traffic light simulation practical model.	2 to 16
7	Temperature control system.	2 to 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 Industrial control circuits	1a. Identify a specified symbols along with their functions in the given industrial control diagram 1b. Explain with sketches the control and power circuit for the given motor control application. 1c. Develop control and power circuits for the specified process control application(s). 1d. Describe the method to troubleshoot the given industrial control circuit.	1.1 Need and benefit of automation, Different input devices such as push button, selector switch, limit switch, proximity switch and pressure switch. 1.2 Different output devices such as relay, contactor, solenoid valve, solid state relay (SSR) 1.3 Different symbols used in industrial control circuits. Concept of control and power circuit diagram. 1.4 Commonly used motor control circuits such as a) DOL starting b) Star-delta starter c) FWD-STOP-REV control and random reversing of induction motor.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		d) Soft Starters 1.6 Typical control and power circuit diagrams of hoist control, conveyer control, lifting magnet and Mill & Extruders.
Unit– II PLC Fundamentals	2a. Describe with sketches the function of a given part of PLC. 2b. Describe the function of the specified part of the given discrete IO module. 2c. Describe the function of the specified part of the given analog IO module. 2d. Describe the functions of the specified part of the given special IO modules. 2e. Compare the salient features of the given two PLCs using block diagrams.	2.1 Function of different parts of PLC such as CPU, memory, power supply and IO modules. 2.2 Digital IO module of PLC, Block diagram and specification 2.3 Analog IO module of PLC, Block diagram and specification 2.4 Special modules of PLC: Communication module PID controller module Stepper motor control module. 2.5 PLCs in market based on CPU type, no of IOs, speed and memory 2.6 Micro PLCs
Unit-III PLC Programming basics	3a. Identify the given parts of the ladder diagram along with the description their functions. 3b. Develop the PLC ladder programs for the given situations. 3c. Describe program scan process for the given type of PLC 3d. Modify the given relay instructions for proper implementation of the given ladder diagram. 3e. Describe the method to troubleshoot the given simple PLC ladder program.	3.1 Binary system, bit, byte, word, logic gates 3.2 Programming PLC using ladder diagram, Components of ladder diagram, Program scan process applied to single rung. 3.3 Ladder diagram for different logic gates. 3.4 Relay type instructions: IF-CLOSED, IF-OPEN Output Energize instructions. Internal relay instructions. 3.7 Timer/counter module: types of timers and counters
Unit –IV PLC Wiring diagrams and Ladder logic	4a. Develop ladder diagrams for the given situation(s). 4b. Select the relevant Input / Output devices required for the given application(s) with justification. 4c. Prepare the relevant wiring diagram for connecting the given type of PLC. 4d. Describe the method to troubleshoot the given PLC ladder	4.1 Seal in circuits using PLC 4.2 Ladder and wiring diagram of DOL starter with OLR 4.3 Latching Relay using PLC 4.4 PLC based water level controller. 4.5 Forward reverse control of 3-phase IM using PLC 4.6 Temperature control ON/OFF 4.7 Stepper motor control. 4.8 Bottle filling system.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	diagram and wiring diagram	4.9 Traffic light control
Unit-V SCADA and DCS	5a. Identify the specified components of the given SCADA System. 5b. Prepare a block diagram of the given architecture of SCADA. 5c. Identify the specified components in the given DCS diagram. 5d. Compare the salient features of given types of SCADA and DCS systems using block diagrams.	5.1 SCADA (Supervisory Control and Data Acquisition) overview. 5.2 Use of HMI. 5.3 SCADA architecture: Monolithic, distributed and networked. 5e. Concept of DCS (Distributed Control System)

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	Industrial control circuits	08	02	06	08	16
II	PLC Fundamentals	10	02	04	08	14
III	PLC Programming basics	10	02	04	08	14
IV	PLC Wiring diagrams and Ladder logic	15	04	06	08	18
V	SCADA and DCS	05	02	02	04	08
Total		48	**12**	**22**	**36**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a) Visit any manufacturing plant having PLC automation.
b) Visit any manufacturing plant with SCADA, HMI.
c) Make a survey of industrial control components based on their ratings.
d) Make a survey of commercially available PLCs.
e) Library / Internet survey of industrial automation circuits and systems.
f) Prepare power point presentation or animation on different automation circuits and their behavior.

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 each topic and subtopics with requirement of automation in industrial environment.
g) Use proper equivalent analogy to explain different concepts.
h) Use PLC simulation software to exhibit mimic of an industrial problem.

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) PLC based induction motor control circuit.
b) PLC based servo motor control.
c) PLC based stepper motor control.
d) PLC based safety system.
e) PLC based closed loop temperature control system.
f) PLC based object counting system.
g) PLC based conveyer control system.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Handbook of Electrical Motor Control Systems	Eswar, U.S.	McGraw Hill Education, New Delhi, 2013, ISBN : 9780074604380
2	Control of Machines	Bhattacharya,	New Age International Publishers,

S. No.	Title of Book	Author	Publication
		S.K.; Singh, B.	New Delhi, 2006, ISBN: 978122418187
3	Programmable Logic Controllers – Principles and Applications	Webb, J.W; Reis,R.A.	PHI learning Pvt. Ltd., New Delhi, 2003; ISBN : 9780130416728
4	Programmable Logic Controllers	Hackworth, J.R.; Hackworth, F.	Pearson Education, New Delhi, 2015, ISBN : 9788177587715
5	Programmable Logic Controllers	Petruzella, F.D.	McGraw Hill Education(India) Edition, New York, 2016, ISBN: 9780073510880
6	Programmable Logic Controllers	Bolton, W.	Elsevier India Pvt, Ltd. New Delhi, 2016, ISBN: 9780128029299
7	Introduction to PLC	Dunning, G.	Cengage India (2009), ISBN: 9788131503027

14. SOFTWARE/LEARNING WEBSITES

a. http://electrical-engineering-portal.com/resources/plc-programming-training
b. PLC Basic Fundamentals and Wiring (Hindi): https://www.youtube.com/watch?v=g7ONCWmRy0w
c. Programmable Logic Controller Basics PLC Professor: https://www.youtube.com/watch?v=PLYosK87D8E
d. Basics of PLC ladder diagram: https://www.youtube.com/watch?v=Hci-eW5IihM
e. Controlling water level by using PLC: https://www.youtube.com/watch?v=1pRv-p_HbRk
f. Traffic signal control using PLC: https://www.youtube.com/watch?v=3WATUnwCwRA
g. Bottle Filling Process using PLC: https://www.youtube.com/watch?v=8UQOhGp8gqY

Program Name : Electrical Engineering Program Group

Program Code : EE/EP/EU

Semester : Fifth

Course Title : Power Electronic Applications (Elective)

Course Code : 22527

1.RATIONALE With rapid development in modern technology, power electronic devices and circuits are integral part of control system. As an electrical engineer it is necessary to exercise control on power given to the machine to control its speed, voltage and current to suit the requirement of various loads. It includes application of power devices such as converters, inverters, induction heating, dielectric heating, electric welding etc. This course aims to impart the knowledge and skills related to handling in terms of the use and maintenance of power electronic devices and circuits.

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 power electronic circuits used in industries.**

3. COURSE OUTCOMES (COs)

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

a. Select power electronic devices for specific application(s).
b. Maintain functioning of the different types of chopper circuits.
c. Maintain functioning of the different types of inverters.
d. Maintain functioning of the different types of dual converters and cyclo-converters.
e. Use power electronic devices in various industrial 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
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.

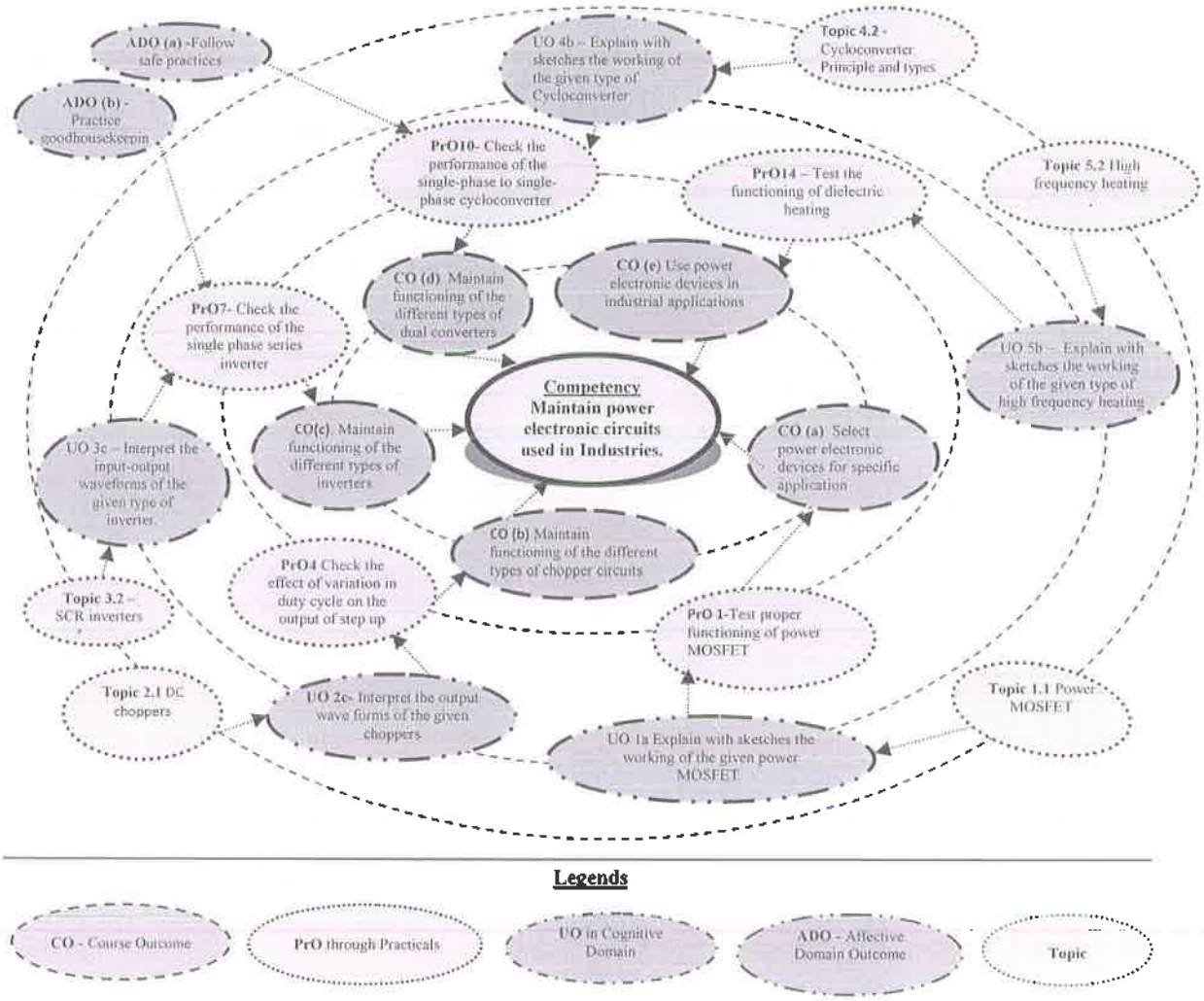

Figure 1 - Course Map

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	Test proper functioning of power MOSFET.	I	02*
2	Test proper functioning of MCT.	I	02*
3	Test proper functioning of SIT.	I	02
4	Check the effect of variation in duty cycle on the output of step up chopper.	II	02*
5	Check the effect of variation in duty cycle on the output of step down chopper.	II	02*
6	Simulate the given chopper circuit in an open source software.	II	02*
7	Check the performance of the single phase series inverter.	III	02*
8	Perform the operation of single phase parallel inverter, observe the output voltage waveform and measure the load voltage.	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Check the performance of the McMurray half bridge inverter.	III	02
10	Check the performance of the single-phase to single-phase cycloconverter.	IV	02*
11	Check the performance of the blocking mode dual converter.	IV	02
12	Simulate the given cycloconverter circuit in an open source software.	IV	02
13	Test the functioning of induction heating.	V	02*
14	Test the functioning of dielectric heating.	V	02*
15	Test the functioning of resistance welding.	V	02*
16	Test the functioning of ac relay type voltage stabilizer.	V	02*
	Total		**32**

Note:

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12or more practical need to be performed, out16 of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

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

S. No.	Performance Indicators	Weightage in %
a.	Correctness of circuit diagrams	40
b.	Troubleshooting ability	20
c.	Quality of input and output displayed (observing , measuring, plotting and analysis of graph/characteristics/parameters)	20
d.	Answer to sample questions	10
e.	Submit report in time	10
Total		**100**

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

a. Follow safe practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

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

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Digital Multimeter:3½ digit, 0-800Volts,0-10A Micro-ammeters:0-100μA	All
2	Dual channel CRO: 25 MHz with isolation transformer OR Power scope , Attenuator probe for CRO	
3	DC Regulated Power Supply: 0-30 V,0-2 A,0-300 V,0- 10 A,	1 to 10
4	Single phase AC supply with 230 V , 10 A.	All
5	Experimental Thyristorised kits related to Choppers, Inverter, Dual converters, Cycloconverter, induction heating, dielectric heating and connecting cords.	All
6	Resistive load:(Lamp-100W,Heater coil- 500W), Resistive-Inductive load: (single phase fractional ¼ HP, 60W/75W Motor), as per requirement of the load.	4 to 12
7	Open Source Software free/License version	6,12

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 Modern power devices	1a. Explain with sketches the working of the given power MOSFET&IGBT. 1b. Interpret the V-I characteristics of the given power electronic device. 1c. Describe the procedure to select suitable power electronic device for given situation with justification. 1d. Describe the procedure to trouble-shoot the given power electronic devices.	1.1 Power MOSFET& IGBT: construction, working, transfer characteristics, output characteristics, and application. 1.2 SCR construction, working, transfer characteristics, output characteristics, and application 1.3 SIT: construction, working, VI characteristics, and application. 1.4 MCT: construction, working, VI characteristics, and application. 1.5 FCT: construction, working, VI characteristics, and application.
Unit– II Chopper circuits	2a. Classify the type of choppers in the given chart. 2b. Compare with sketches the working of the given type of choppers. 2c. Interpret the output wave forms of the given choppers. 2d. Explain the effects of saturable core reactor in the given type of dual converter. 2e. Describe with sketches the	2.1 DC choppers: Types 2.2 Control strategies of chopper 2.3 Single quadrant, two quadrant, four quadrant chopper (circuit diagram, operation with waveforms) 2.4 Morgan chopper: circuit diagram, operation with waveforms. 2.5 Jones choppers: circuit diagram, operation with waveforms.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	procedure to troubleshoot the given chopper circuits.	
Unit– III Inverter circuits	3a. Explain with sketches the function of the given type of inverter. 3b. Calculate the output voltage and current for the given parameters of the inverter. 3c. Interpret the input-output waveforms of the given type of inverter. 3d. Describe with sketches the effects of the magnetically coupled inductor in the given McMurray-Bedford inverter with sketches. 3e. Describe with sketches the procedure to troubleshoot the given inverters.	3.1 Classification: Voltage-driven and current-driven inverter. 3.2 Transistor inverter, SCR inverters: Single-phase parallel inverter, single-phase series inverter, single phase bridge inverter description with circuits and waveforms. 3.3 Three-phase bridge inverter description with circuits and waveforms. 3.4 McMurray half bridge and full bridge inverters description with circuits and waveforms. 3.5 McMurray-Bedford inverter description with circuits and waveforms and applications.
Unit-IV Dual converters and Cycloconverters	4a. Explain with sketches the working of the given type of dual converters. 4b. Explain with sketches the working of the given type of Cyclo-converter. 4c. Select Dual converter and Cyclo-converter on the basis of applications with justification. 4d. Interpret the waveforms of the given type of Cyclo-converter.	4.1 Dual converters: Principle and types. 4.2 Circulatory current free mode, circulatory current mode dual converters. 4.3 Cyclo-converter: Principle and types. 4.4 Single phase to single phase and three phase Cyclo-converter: operation with circuit and waveforms.
Unit –V Industrial Applications of Power devices	5a. Explain with sketches the working of the given type of static circuit breaker. 5b. Explain with sketches the working of the given type of high frequency heating. 5c. Explain with sketches the working of the given type of AC voltage stabilizer. 5d. Describe speed control method for given servomotor. 5e. Simulation of chopper, Inverter and Cyclo-converter circuits.	5.1 Static circuit breaker(DC and AC). 5.2 High frequency heating: induction heating and dielectric heating control. 5.3 Electric welding control. 5.4 Battery charger control. 5.5 AC voltage stabilizer type: servo , solid state and relay. 5.6 Static VAR compensation system. 5.7 Closed loop speed control method for DC and AC servo motor. 5.8 Simulation: chopper, Inverter and Cyclo-converter circuits.

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

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Modern power devices	06	02	02	04	08
II	Chopper circuits	10	02	06	08	16
III	Inverter circuits	10	02	06	08	16
IV	Dual converters and Cyclo converters	10	02	08	04	14
V	Industrial applications of power devices.	12	04	04	08	16
Total		**48**	**12**	**26**	**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. Visit the nearby power electronics based industry and observe the processes.
b. Take the market survey of various specifications of available power devices and submit the report.
c. Survey the market and submit the report of availablechoppers,inverters,dual converters and Cycloconverters.
d. Use internet to submit the report of various industrial control circuits.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning 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 LOs/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 to the student 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 work and micro project related activities.
i. Use simulation software's for demonstrating the performance of different power devices.

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. **Automatic street light :** Build and test the circuit of automatic street light.
b. **Choppers:** Build and test the Jones chopper circuit.
c. **Inverters :** Construct and test a circuit of thyristorised inverter and simulate using Scilab.
d. **Dual converters and Cyclo-converters:** Build and test the circuit of three phase to single phase Cyclo-converter.
e. **Speed control of AC/DC motor**: Build and test the speed control of DC motor using power electronic devices.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Modern Power Electronics	Sen P.C.	S. Chand & Company, New Delhi; 2013, ISBN: 978-8121924252.
2	Thyristors: Theory and Applications	Sugandhi R. K. and Sugandhi K. K.	New Age International Publishers, New Delhi, 2009, ISBN:978-0852268520.
3	Power Electronics and its Applications	Jain Alok	Penram International Publishing Mumbai, 2006; ISBN: 978-8187972228.
4	Power Electronics Circuits Devices and Applications	Rashid , Muhammad H.	Pearson Education India, Noida, 2014; ISBN: 978-0133125900.
5	Power Electronics	Singh, M. D. and Khanchandani, K.B.	McGraw Hill Publishing Co. Ltd, New Delhi, 2008 ISBN: 978-0070583894.
6	Power Electronics	Bimbhra P.S.	Khanna Publication

S. No.	Title of Book	Author	Publication
			New Delhi,2008 ISBN-13:978-8174092793

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.nptel.ac.in/courses/108101038
b. www.ee.iitb.ac.in/~apel/
c. www.tutorialspoint.com/power_electronics/
d. MATLAB: Software for Power Electronics Simulation
e. www.nptelvideos.in/2012/11/power-electronics.html
f. www.electrical4u.com/thyristor-triggering/
g. www.powerguru.org/power-electronics-videos/
h. www.youtube.com/watch?v=1Auay7ja2oY

Program Name : **Electrical Engineering Program Group**

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

Semester : **Fifth**

Course Title : **Wind Power Technologies (Elective)**

Course Code : **22528**

1. RATIONALE

Indian energy sector is undergoing a transition with wind power becoming a major energy source in the country with the establishment of large and small wind farms spread all across the country. Wind power plants have become a choice for generating clean and green electricity. Further, with a large number of large and small wind turbine manufacturers, there is a dearth of qualified and trained technologists who can manufacture and maintain the large and small wind turbines. This curriculum is designed in such a way that a technologist will be able to maintain the routine problems of related to large wind power plants and small wind turbines.

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 large wind power plants and small wind turbines.**

3. COURSE OUTCOMES (COs)

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

a. Identify the various types of wind power plants and their auxiliaries.
b. Maintain the normal working of large wind turbines.
c. Optimise the aerodynamic and electric control of large wind power plants.
d. Troubleshoot the common faults of large wind power plants.
e. Maintain the normal working of small wind turbines.
f. Troubleshoot small wind turbines.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

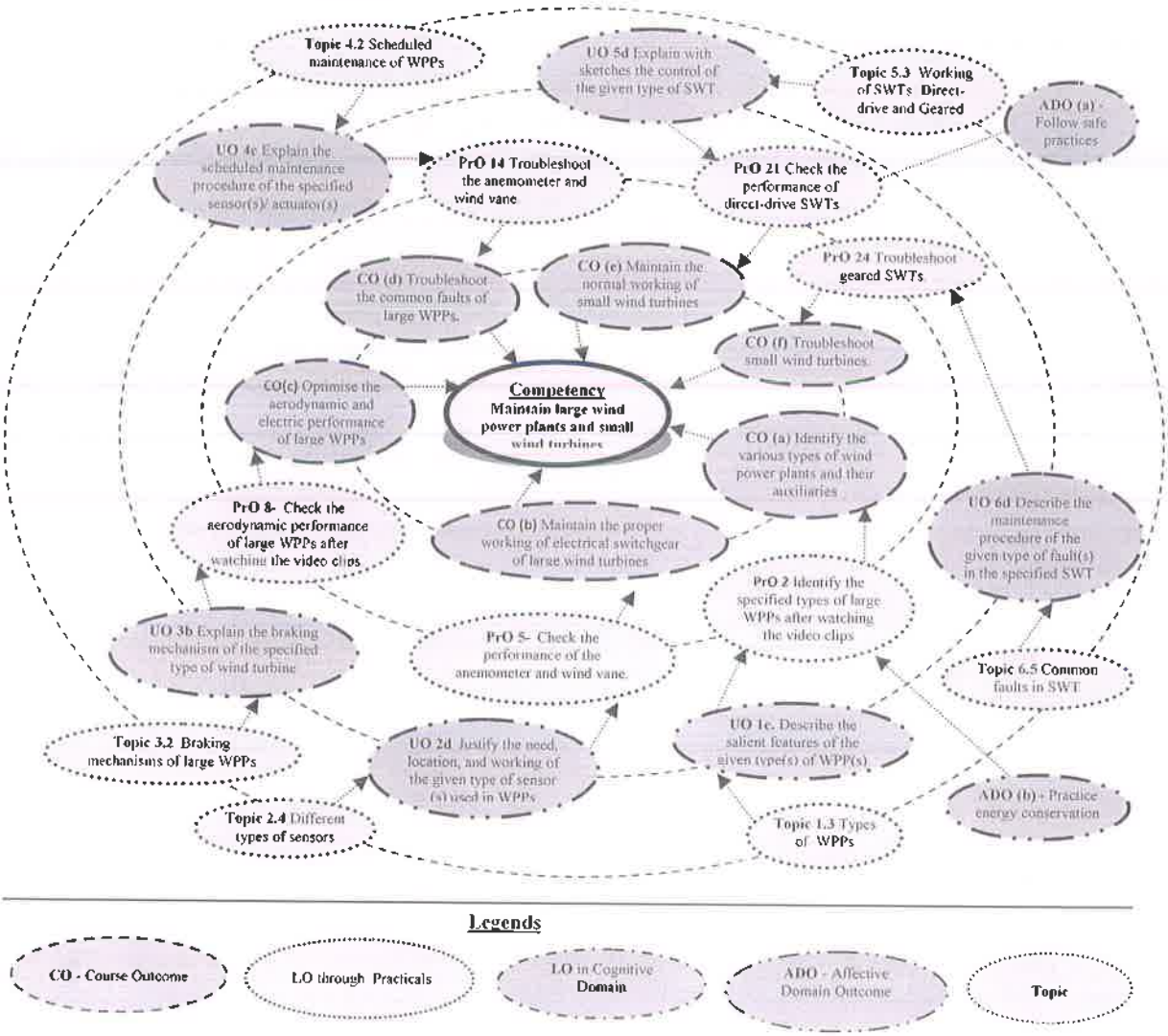

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the specified items of a wind farm after watching the video clip.	I	02*
2	Identify the specified types of large WPPs after watching the video clips.	I	02
3	Identify the specified parts inside the nacelle of a large wind power plant after watching the video clips.	II	02*
4	Identify the specified parts of the electrical switchyard of a large wind power plant after watching the video clip.	II	02
5	Check the aerodynamic performance of large WPPs after watching	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	the video clips.		
6	Check the performance of the temperature and vibration sensor used in 125/150 kW WPPs.	III	02*
7	Check the performance of the SCIG	III	02*
8	Check the performance of the DFIG	III	02
9	Check the performance of the PMSG	III	02*
10	Check the performance of the hydraulic and electric pitch actuator and yaw actuator used in 125/150 kW WPPs.	IV	02*
11	Check the performance of the contactless RPM sensors used in WPPs	IV	02
12	Identify the specified parts which require routing maintenance, oiling and greasing, of the large wind power plants after watching the video clips.	IV	02*
13	Troubleshoot the anemometer and wind vane	IV	02*
14	Check the generator performance of SWTs.	V	02
15	Identify the parts of a direct-drive SWT	V	02*
16	Identify the parts of a geared SWT	V	02*
17	Dismantle a direct-drive SWT	VI	02*
18	Assemble a direct-drive SWT	VI	02
19	Dismantle a geared SWT	VI	02*
20	Assemble a geared SWT	VI	02
21	Check the performance of direct-drive SWT	V	02
22	Check the performance of geared SWT	V	02
23	Simulate faults in the small wind turbine trainer	V	02*
24	Troubleshoot direct-drive SWT	VI	02
25	Troubleshoot geared SWT	VI	02
26	Interpret the wiring of a SWT electric-electronic control panel	VI	02
	Total		**52**

Note

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

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

S. No.	Performance Indicators	Weightage in %
1	Selection of suitable components, apparatus/instruments	20
2	Preparation of experimental setup	10
3	Setting and Operation	10
4	Safety measures	10
5	Observations and recordings	10
6	Interpretation of results and calculations	20
7	Answer to sample questions	10
8	Submission of report in time	10
	Total	100

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

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

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

- 'Valuing Level' in 1st year
- '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. S. No.
1	Video programmes of construction and working of large wind power plants.	1 to 4, 8
2	Second hand or new Nacelle of 150 kW to 500 kW wind turbine	3,12
3	Second hand or new 150 to 500 kW Wind turbine gear box	3,12
4	Second hand or new 150 to 500 kW Wind turbine electronic control panel	4
5	Thyristors used in 150 to 500 kW Wind turbine	4
6	Second hand or new 150 to 500 kW Wind turbine power electronic control panel	4
7	3-Cup type wind anemometer	13
8	Ultra sonic anemometer	13
9	Wind vane	13
10	Vibration sensor used in WPP	6
11	Temperature sensors of Gearbox, electric generator, ambient temperature used in WPP	6
12	RPM sensors of rotor and electric generator used in WPP	11
13	Hydraulic and electric pitch sensor and actuators used in WPP	10,12
14	3kW to 5 kW direct-drive small wind turbine with permanent magnet electric generator	14, 17, 18, 23
15	10 kW to 15 kW small wind turbine with gearbox and induction generator	16,19, 20, 24
16	10 kW to 15 kW small wind turbine electric-electronic control panel.	24 to 26
17	Small wind turbine trainer	23

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 Wind Energy and Wind Power Plants	1a. Describe the India's wind power ranking in (name the year) compared to the world ranking, as well as the ranking between the states in India during the same year using pie chart sketches or bar charts. 1b. Explain the specified characteristics of the wind related to wind power generation 1c. Describe the salient features of the given type(s) of WPP(s). 1d. Explain the need for the specified component of the electric sub-station.	1.1 Wind power scenario in the world and India 1.2 **Characteristics of Wind Energy**: Wind movement, wind profile, roughness, effects of obstacles in wind path. 1.3 **Types of Wind Power Plants (WPPs)**: Small and large wind turbines; Horizontal and Vertical axis; Upwind and Downwind, One, Two and Three blades; constant and variable Speed; Geared, Direct-Drive and Semi-Geared (Hybrid) WPPs; WECS, WEGs, WTs, WPPs, 1.4 **WPP Tower Types**: Lattice; tubular: steel, concrete, hybrid, ladders, cables. 1.5 **WPP substation:** Switchgear, transformers, inside layouts of Electric electronic panels at block level.
Unit– II Construction and Working of Large Wind Power Plants	2a. Explain the given terms related to wind power. 2b. Describe the function(s) of the specified WPP component(s). 2c. Explain with sketches the specified principle of the rotation of the wind turbine rotor. 2d. Justify the need, location, and working of the given type of sensor (s) used in WPPs. 2e. Explain the need and working of the given type of actuator(s) used in WPPs.	2.1 **Wind Turbine Terminologies:** Cut-in, cut-out and survival wind speeds, Threshold wind speeds, rated power, nominal power, Wind Power Curve, 2.2 **Major parts and Functions of WPP:** Rotor blades, hub, nacelle, tower, electric sub-station, nacelle layouts of Geared, Direct-Drive and Semi-Geared WPPs, Main shaft, gearbox, electric generator, electronic control panels 2.3 **Rotation principles**: Drag and Lift principle, thrust and torque of wind turbine rotor. 2.4 **Different types of Sensors**: Anemometer, wind vane, rpm sensors of main shaft and generator, temperature sensors of nacelle, gearbox and generator; cable untwisting and vibration sensors 2.5 **Different types of Actuators**: Electric and hydraulic pitching and yawing mechanisms, cable untwisting and braking mechanisms
Unit– III Aerodynamic Control, Electric Generators and Grid Connection	3a. Distinguish the specified type of aerodynamic control also using the wind power curve. 3b. Explain with sketches the braking mechanism of the specified type of wind turbine. 3c. Explain with sketches the	3.1 Aerodynamic Control of WPPs: Stall, Pitch and Active Stall. 3.2 Braking mechanisms of large WPPs. 3.3 **Electric Generator Types**: Working of Squirrel-Cage rotor Induction Generator (SCIG), Wound-Rotor Induction Generator (WRIG), Doubly-Fed Induction Generator (DFIG), wound rotor and permanent magnet synchronous generators.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	working of the given type of electric generator used in large WPPs. 3d. Explain the impact of the specified problem when connecting the WPP to the grid.	3.4 Electric grid connection of WPPs: Local Impacts and system wide impact
Unit– IV Maintenance of Large Wind Power Plants	4a. Explain the procedure of preventive maintenance of the given WPP component. 4b. Describe the general maintenance issues of the specified type of WPP(s) 4c. Explain the scheduled maintenance procedure of the specified sensor(s)/ actuator(s). 4d. Explain the procedure of the unscheduled maintenance of the specified WPP component(s).	4.1 **General maintenance of WPPs:** preventive maintenance schedule of actuators such as yaw control, pitch control, braking mechanisms and sensors; oiling and greasing; electric and electronic equipment related; tower related; minor repairs, some tips, 4.2 **Scheduled Maintenance:** of Stall and Pitch and Active Pitch controlled WPPs 4.3 **Unscheduled maintenance**: operational factors, design faults, wear and tear of components, spurious trip, Major repairs. 4.4 Software related, warranty and insurance related issues
Unit– V Construction and Working Small Wind Turbines	5a. Distinguish the features of the given types of small wind turbines. 5b. Describe with sketches the functions of the given part(s) of the specified SWT. 5c. Explain with sketches the blade rotation of the given type of SWT. 5d. Explain with sketches the control of the given type of SWT. 5e. Describe with sketches the features towers of the given type(s) of SWT. 5f. Explain with sketches the working of the given type of electric generator used in SWT.	5.1 **Types and working of different type of small wind turbines (SWT):** Classification: Horizontal and Vertical axis, Upwind and Downwind, One, Two and Three blades; Constant and Variable Speed; Direct-Drive and Geared; braking of SWTs 5.2 **Parts of SWTs:** Rotor, generator, gearbox, tower, electric control panel, tale vane, anemometer, wind vane, temperature and rpm sensors. 5.3 **Working SWTs:** Direct-drive and Geared. 5.4 **Electrical generators in SWTs**: permanent magnet synchronous generators, induction generators 5.5 **SWT towers:** Lattice tubular type, hydraulic towers, ladders, cables.
Unit-VI Maintenance of Small Wind Turbines	6a. Describe the installation of the specified SWT. 6b. Identify the power electronic device(s) in the given SWT with justification	6.1 Small wind turbine assembly. 6.2 Installation of different types of small wind turbines (SWT): tubular and lattice types. 6.3 **SWT Routine maintenance:** Tips; Preventive maintenance schedule of braking mechanisms, sensors; oiling and

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	6c. Describe the function of the given type of power electronic converter in the specified type of SWT 6d. Describe the maintenance procedure of the given type of fault(s) in the specified SWT.	greasing related; electric and electronic equipment related; tower related; software related, minor repairs 6.4 Power electronic devices and converters in different types of SWTs: thyristors, power transistors 6.5 Common mechanical faults in SWTs 6.6 Common electrical faults in s SWTs

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	Wind Energy and Wind Power Plants	04	02	02	04	08
II	Construction and Working of Large Wind Power Plants	08	02	04	06	12
III	Aerodynamic Control, Electric Generators and Grid Connection	10	02	06	08	16
IV	Maintenance of Large Wind Power Plants	08	02	04	06	12
V	Construction and Working Small Wind Turbines	10	02	04	08	14
VI	Maintenance of Small Wind Turbines	08	02	02	04	08
Total		**48**	**12**	**22**	**36**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Prepare journal of practicals.
b. 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***.
a. Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

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

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

a. Case study of any large wind power plant.
b. Study of gearboxes used in large WPPs.
c. Study of electric generators used in large WPPs
d. Study of towers used large WPPs
e. Study of electric switchyards used in large WPPs.
f. Comparative study of SWTs.
g. Comparative study of towers used in SWTs

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi, 2015, ISBN: 978-8120351660
2	Wind Turbines	Hau, Erich	Springer-Verlag, Berlin Heidelberg, Germany, 2013, ISBN: 978-3-642-27150-2
3	Wind Power Plants and Project Development	Earnest, Joshua	PHI Learning, New Delhi, 2015, ISBN: 978-8120351271
4	Wind Energy Basics	Gipe, Paul	Chelsea Green Publishing Co;2009, ISBN: 978-1603580304
5	Wind Electrical Systems	Bhadra, S.N., Kastha, D., Banerjee, S.	Oxford University Press, New Delhi 2013, ISBN: 9780195670936
6	Wind Energy	Siraj Ahmed	PHI Learning, New Delhi, 2015 ISBN: 978-8120351639

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=FSB8_pb88P8
b. https://www.youtube.com/watch?v=P9SyZvHrJvc
c. https://www.youtube.com/watch?v=A-k2YGrpATo
d. https://www.youtube.com/watch?v=qSWm_nprfqE
e. https://www.youtube.com/watch?v=LNXTm7aHvWc
f. https://www.youtube.com/watch?v=x3AfhSHAcqg
g. https://www.youtube.com/watch?v=vN5Fdv_OKd0
h. https://www.youtube.com/watch?v=hXcgvKpDyzs
i. https://www.youtube.com/watch?v=c5sG1cMhSNw
j. https://www.youtube.com/watch?v=45Xh7FKS9nM (small wind turbine)
k. https://www.youtube.com/watch?v=j_fViOJbJLk (small wind turbine)
l. http://mnre.gov.in/file-manager/grid-wind/guideline-wind.pdf

Program Name : Electrical Engineering Program Group

Program Code : EE/EP/EU

Semester : Fifth

Course Title : Power System Analysis (Elective)

Course Code : 22529

1. RATIONALE

The diploma engineers working in power sector, while undertaking major activities related to transmission and distribution systems they should be able to interpret significance of the activities assigned to them. For example, they should be aware of active and reactive power flow and methods to analyze performance of power system. They should also be able to represent power system components in circuit form and analysiswith the concept of 'Generalize Circuit'. They should adopt per-unit system calculations for power system analysis.Hence, this course is designed to enable diploma pass outs to handle different activities in power system sector with appropriate power flow perceptive. Thus this course is important for diploma electrical engineers who wish to work in power generation, transmission and distribution companies.

2. COMPETENCY

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

- **Maintain powersystem networks within power flow strategies.**

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 circuits for various components ofthe power system.
b. Calculate line parameters for different types of transmission lines.
c. Use generalised circuit calculations for transmission line performance.
d. Estimate the power at sending and receiving ends of transmission line.
e. Ensureperformance of transmission lines by graphical analysis.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

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

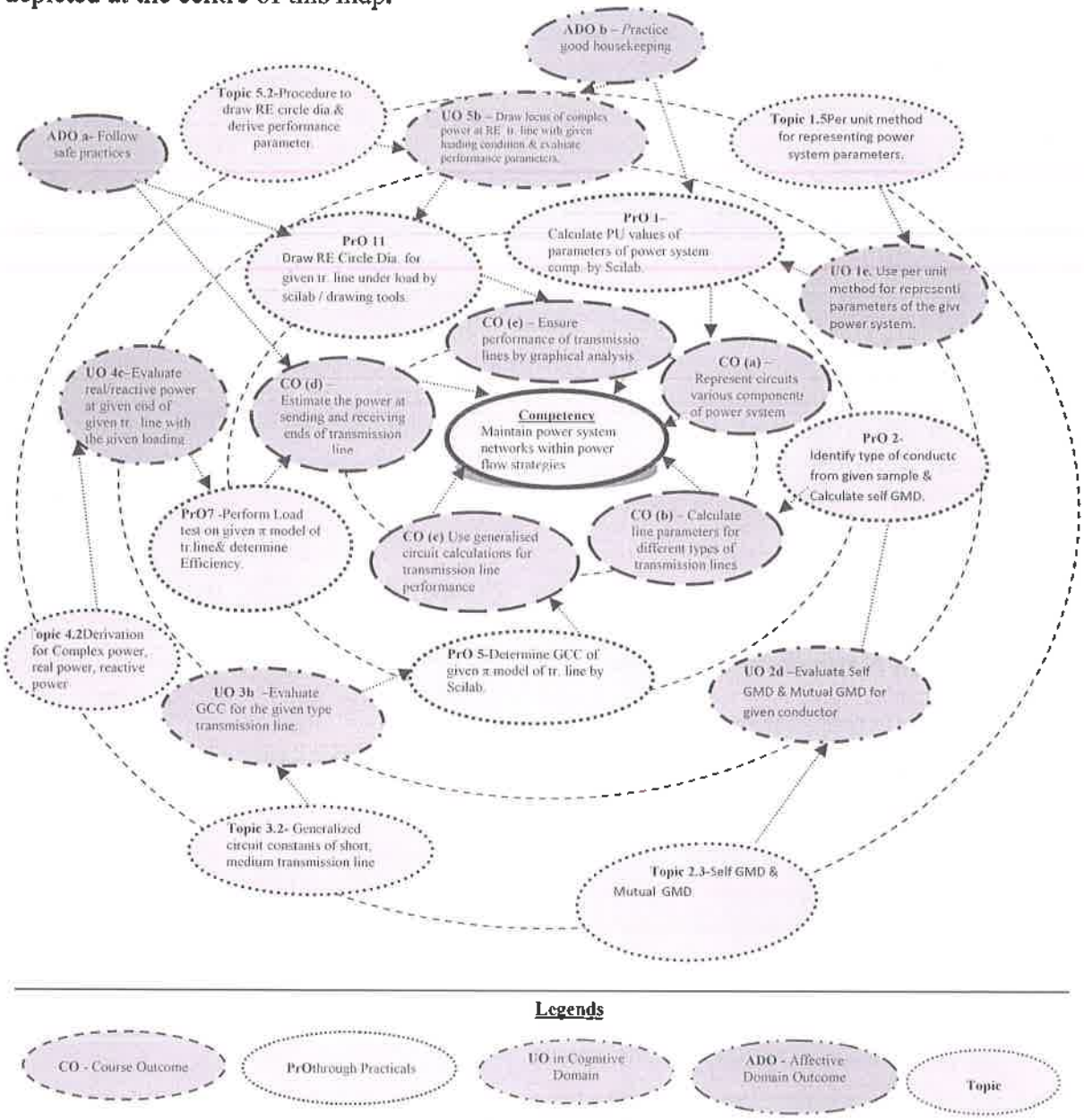

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Calculate per unit values of parameters of power system components for given power system by using Scilab.	I	02*
2	Identify type of conductor from given sample of line conductors and Calculate self GMD.	II	04*
3	Perform OC and SC Test and evaluate Generalized circuit constant	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	of given π model of transmission line.		
4	Perform OC and SC Test and evaluate Generalized circuit constant of given T model of transmission line.	III	02*
5	Determine Generalized circuit constant of given π model of transmission line by using Scilab.	III	02*
6	Determine Generalized circuit constant of given T model of transmission line by using Scilab	III	02
7	Perform Load test on given π model of transmission line and determine the Efficiency.	IV	02*
8	Perform Load test on given T model of transmission line and determine the efficiency.	IV	02
9	Evaluate Receiving end complex power by using Scilab for given transmission line under load condition	IV	02*
10	Evaluate Sending end complex power by using Scilab for given transmission line under given condition	IV	02*
11	Draw Receiving end Circle Diagram for given transmission line under load condition by using scilab / drawing tools.	V	02*
12	Draw Sending end Circle Diagram for given transmission line under given condition by using scilab / drawing tools.	V	02
13	Observe the effect of reactive power consumption by single phase split phase Induction motor connecting capacitor bank (REC).	V	02*
14	Observe the videos on reactive power compensation Equipmentsand prepare informative report.(part-1)	V	02
15	Observe the videos on reactive power compensation Equipments and prepare informative report. .(part-2)	V	02
	Total		**32**

Note

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

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

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	20
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. Maintain tools and equipment.
f. Follow ethical Practices.

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

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- '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	Open source software Scilab 5.5.2 (any other s uitable software)	1, 5,6, 9,10,11,12
2	Sample of transmission line conductors	2
3	Simulation π model of transmission line or trainer kit	3,7
4	Simulation T model of transmission line or trainer kit.	4,8
5	AC ammeter 2.5A, 5A	3,4,7,8,13
6	AC voltmeter 30V, 300V	3,4,7,8,13
7	Single Phase Wattmeter –Lpf 2.5A,300 V and unity pf 5A ,75/300V	3,4,7,8,13
8	Single Phase Auto transformer 0-250 V,10A	3,4
9	Lamp Bank 1KW, 230 V, 5A	7,8
10	Single phase split phase induction motor 1HP (Any other Suitable Motor)	13
11	Capacitor Bank	13
12	LCD projector, PC Arrangement with audio system.	14,2
13	Videos on reactive power compensation equipments.	14

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopicsshould betaught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Representation of power system.	1a. Explain the specified aspects of the given power system. 1b. Describe role of power system engineer for analysing the given power system. 1c. Draw the Equivalent circuit of the given power system components. 1d. Develop impedance diagram and reactance diagram from the given single line diagram of power system. 1e. Use per unit method for representing parameters of the given power system.	1.1 Aspects of power system analysis: 1.2 Role of power system engineer. 1.3 Equivalent Circuit representation of the System components-Alternator, Transformer, Load, Transmission line: Short, Medium and long. 1.4 Representation of power system by single line diagram, impedance diagram and reactance diagram. 1.5 Per unit method for representing power system parameters.
Unit– II Composition of Transmission Line	2a. Develop composition of the given transmission line 2b. Describe the impact of given parameter in transmission line performance. 2c. Calculate inductance of the given single phase line with given configuration. 2d. Evaluate Self GMD andMutual GMD for given conductor configuration. 2e. Develop the equation for inductance/capacitance of given transmission line 2f. Estimate the inductance/capacitance of three phase line for the given conductor arrangement.	2.1 Transmission line composition – resistance, inductance, capacitance and conductance and their significance. 2.2 Inductance-Single phase line composed of solid conductors and bundled conductors. 2.3 Self GMD and Mutual GMD 2.4 Inductance of three phase line (single circuit) composed of solid conductors with symmetrical and asymmetrical spacing. 2.5 Capacitance of single phase line composed of solid Conductors and Duplex bundled conductors. 2.6 Capacitance of three phase line (single circuit) with symmetrical and asymmetrical spacing. 2.7 Effect of earth field on transmission line capacitance.
Unit-III Generalized circuit representation	3a. Apply concept of generalized circuit for the given type transmission line. 3b. Evaluate the generalized circuit constants for the given type transmission line. 3c. Develop resultant generalized network of the given type combination of networks. 3d. Describe the benefits of generalised circuit representation of the given type of transmission line.	3.1 Generalized Circuit – Concept 3.2 Generalized circuit constants of short, mediumtransmission line. 3.3 Generalized circuit constants of two networks connected in series 3.4 Generalized circuit constants of two networks connected in parallel. 3.5 Advantages of Generalized circuit representation

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit –IV Power flow	4a. Describe the concept of complex power with reference to the given power system. 4b. Develop the expression for complex power at given end of given transmission line. 4c. Evaluate real/reactive power at given end of given transmission line forthe given loading condition. 4d. Develop the condition for maximum real power flow of given end of the given transmission line.	4.1 Complex Power ($S=V I^{*}$), Real Power and reactive Power. 4.2 Derivation for Complex power, real power, reactive power for receiving end of the tr. line using GCE. 4.3 Derivation for Complex power, real power, reactive power for sending end of the tr. line using GCE. 4.4 Condition for maximum powerat receiving end of transmission line. 4.5 Condition for maximum power at sending end of transmission line.
Unit-V Line performance by graphical analysis	5a. Describe the locus of complex power flowing through transmission line at both end 5b. Draw locus of complex power at receiving end transmission line with given loading conditionand evaluate performance parameters. 5c. Draw locus of complex power at Sending end transmission line with given condition and evaluate performance parameters. 5d. Identify the relevant reactive power compensating equipment for the given power system condition. 5e. Determine ratings of reactive power compensating equipment for given transmission line data.	5.1 Graphical method for Transmission line performance analysis- Receiving end circle diagramand Sending end circle diagram 5.2 Procedure to draw Receiving end circle diagram and derive performance parameter. 5.3 Procedure to draw Sending end circle diagram and derive performance parameter. 5.4 Reactive power compensation-Necessityand types ofequipments 5.5 Rating of equipment using receiving end circle diagram. 5.6 Advantages of graphical analysis

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	Representation of power system	07	00	04	04	08
II	Composition of Transmission Line	16	04	06	06	16
III	Generalized circuit representation	09	04	06	08	18
IV	Power flow	07	02	06	08	16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
V	Line performance by graphical analysis	09	02	04	06	12
Total		**48**	**12**	**26**	**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 reactive power compensation 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 understandvarious transmission line systems and write a technical report.
c. Collect data of different types of conductors used for different types of transmission lines through internet/ industrial visit.
d. Write all the safety precautionswhich are to be taken while working with distribution & transmission lines.
e. Collect information regarding maintenance of transmission lines. 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 all units with subtopics of other units.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain reactive power compensation concept.
i. Use open source Scilab software to explain different concepts of power flow.

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. **Reactive Power compensation scheme**: Collect the information and Prepare comparative chart.
b. **Case study on power flow:** Performance analysis by analytical and graphical method for given loading condition.
c. **Representation in Generalized circuit:**Represent the given transmission line in generalized circuit and evaluate constants.
d. **Information collection**: Collect information of existing EHV transmission line and prepare report.
e. **Development of circuit model of Transmission line:** Evaluate line parameters from given design of transmission line and represent circuit model.

13. SUGGESTED LEARNING RESOURCES:

S. No.	Title of Book	Author	Publication
1	Principles of Power System	Mehta V. K ; Mehta Rohit.	S.Chand and Co., New Delhi. ISBN: 978-81-2192-496-2.
2	Modern Power System Analysis	NagrathI. J. Kothari D. P.	McGraw HillEducation, New Delhi 2003.ISBN-0-07-049489-4
3	Elements of Power System Analysis e-book	Stevenson William	McGraw-Hill Book Company, New York, 2014(4th addition) ISBN 10: 0070612781 / ISBN 13: 9780070612785
4	Electrical Power System	WadhavaC. L.	New age international publishers ISBN: 13-978-1-4987-7757-5-(EPUB)
5	Power System Protection and Switchgear	Badri Ram Vishwakarma D. N.	McGraw-Hill, New Delhi. ISBN : 978-07-107774-X
6	Power system Analysis and Design	Gupta B.R.	S. Chand and Co. Ltd., New Delhi Edition: 6 Year: 2011 ISBN: 81-219-2238-0

14. SOFTWARE/LEARNING WEBSITES

a. Lecture series on power system https://nptel.ac.in
b. Lecture series on power system https://www.youtube.com/watch?v=fBmtdr_gRBk
c. https://circuitglobe.com/power-system.html
d. https://www.electrical4u.com/power-system

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.

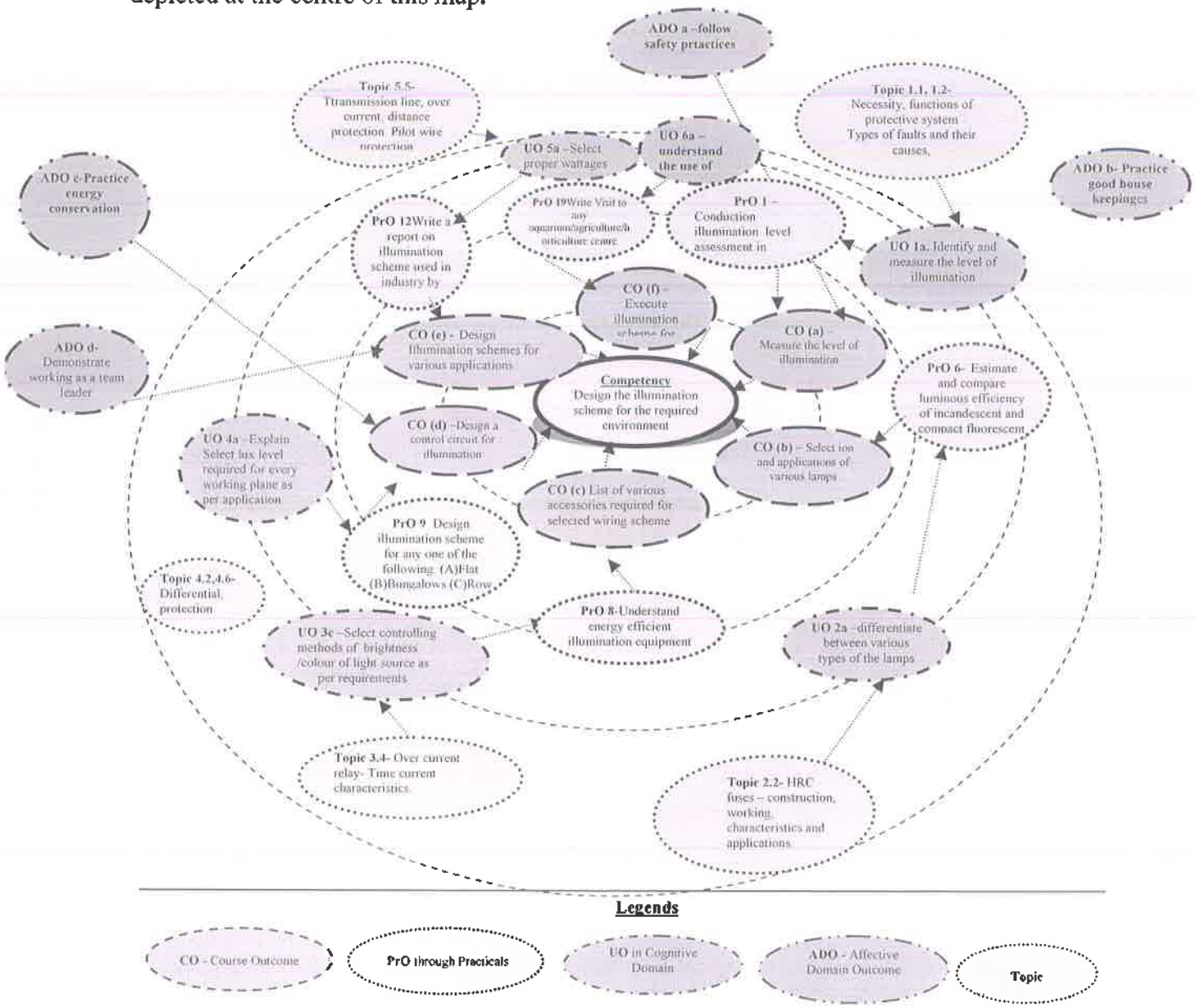

Figure 1 - Course Map

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 : **Diploma in Automobile Engineering / Civil Engineering Group / Electronics Engineering Group / Diploma in Plastic Engineering / Diploma in Production Engineering /Diploma in Fashion & Clothing Technology/ Computer Engineering Group**

Program Code : **AE/CE/CR/CS/ DE/EJ/ET/EN/EX/EQ/IS/IC/IE/PG/PT/DC/ CO/CM/CW/IF**

Semester : **Sixth**

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.

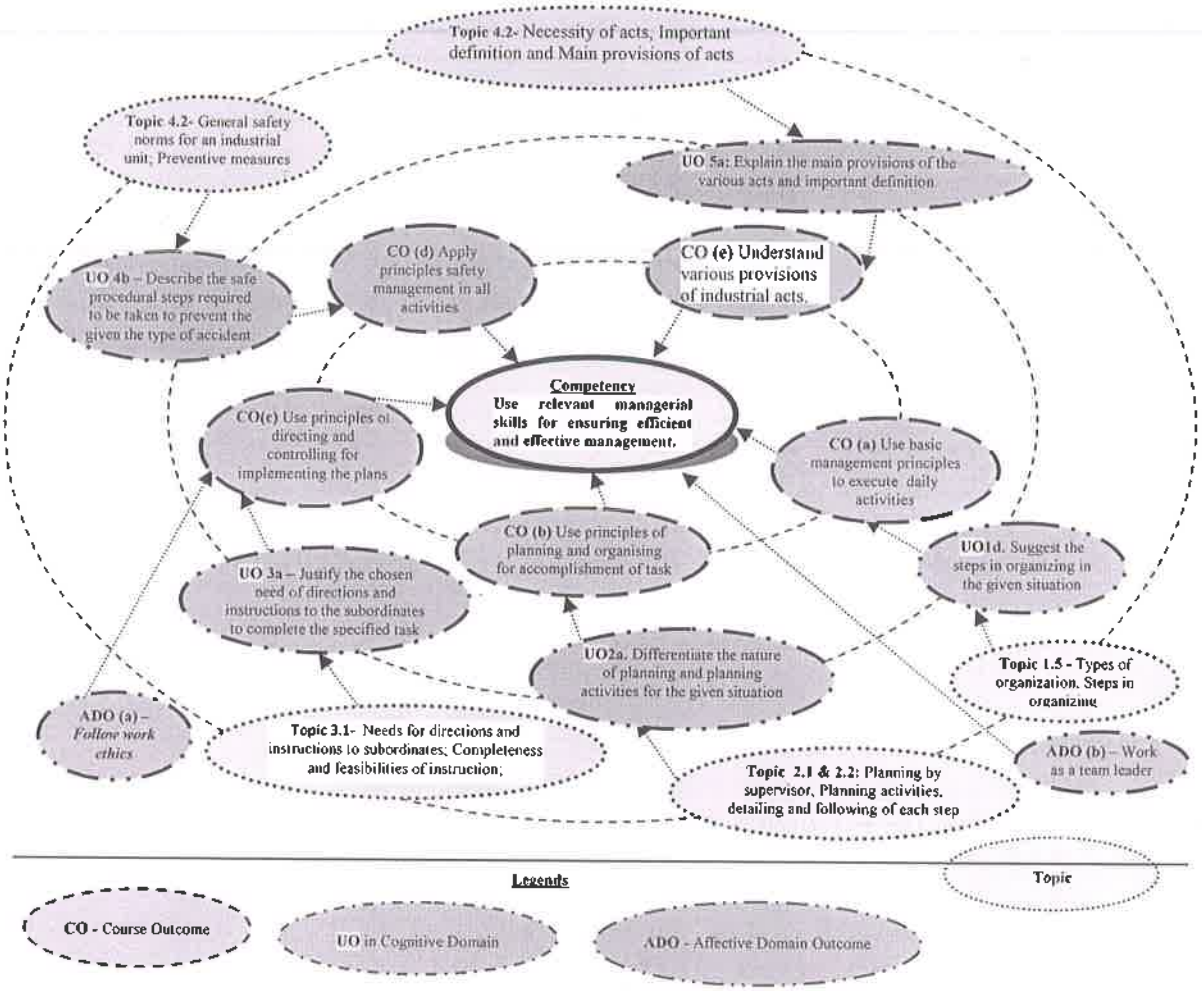

Figure 1 - Course Map

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