

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021) Semester-VI

**COURSE TITLE: ELECTRICAL INSTALLATION, COMMISSIONING AND
MAINTENANCE (E.I.C. & M.)
(Course Code: 4360901)**

Diploma Program in which this course is offered	Semester in which offered
Electrical Engineering	Sixth (6 th)

1. RATIONALE:

Electrical Power system and Electrical system in industry & commercial places comprises of numerous electrical apparatus and equipment at distinct stages as well as in vicinity of other apparatus or equipment like transformers, rotating machines, circuit breakers and other equipment's which require installation, commissioning and regular maintenance to prevent permanent break down. Many times, an engineering diploma holder has to carryout/supervise installation, commissioning and maintenance of various electrical equipments in power stations, substations as well as industry. This course will enable the diploma pass out student to understand the significance of appropriate procedure of installation, commissioning and maintenance of electrical equipments, concepts, principles along with acquiring basic skills of installation, commissioning and maintenance of electrical equipments in power stations, substations and industry by means of experimentation.

2. COMPETENCY:

The basic objective of this course is to develop required skills among the students so that they are able to acquire following competency:

- ❖ **Undertake installation, commissioning and maintenance of various electrical Equipments and Machines**

3. COURSE OUTCOMES (COs):

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

- i. Install various electrical equipments/machines.
- ii. Commission & Test various electrical equipments/machines
- iii. Carryout maintenance of different electrical equipments and machines.
- iv. Troubleshoot various electrical equipments/machines and domestic electrical appliances.
- v. Apply electrical earthing, safety rules and safety practices.

4. TEACHING AND EXAMINATION SCHEME:

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
L	T	P		Theory Marks		Practical Marks		Total Marks
			C	CA	ESE	CA	ESE	
3	0	2	4	30	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be conducted during the semester for the assessing the attainment 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, CA - Continuous Assessment; ESE - End Semester Examination.

5. SUGGESTED PRACTICAL EXERCISES:

The following practical outcomes (PrOs) that are the sub-components of the COs. Some of the PrOs marked ‘*’ are compulsory, as they are crucial for that particular CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Prepare layouts of wiring and plan pre-erection activity for installation of different electrical machine with specification in your Electrical machine Laboratory	1	2*
2.	Perform BDV test on insulating oil used in power transformer	2	2
3.	Measure insulation resistance of a winding/cables/wiring installation	2	2*
4.	Prepare test report of three phase transformer after commissioning	2	2*
5.	Prepare test report of three phase induction motor after commissioning	2	2
6.	Prepare test report of vacuum circuit breaker after commissioning	2	2*
7.	Prepare maintenance schedule for power transformer	3	2*
8.	Prepare maintenance schedule for three phase induction motor	3	2*
9.	Prepare maintenance schedule for Circuit Breaker	3	2
10.	Trouble shoot for DC Motor- Generator set available in your Electrical machine laboratory.	4	2*
11.	Trouble shoot for three phase Induction Motor- Alternator set with DOL starter available in your Electrical machine lab.	4	2*
12.	Trouble shoot for vacuum circuit breaker for 11 KV bus bar system	4	2
13.	Measure earth resistance of installation of building/domestic wiring and appliances by different methods	5	2*
14.	Demonstrate plate/pipe earthing as per IS and measure the earth resistance	5	2
15.	Enlist the action and remedy to be taken when a person comes in contact with a live wire	5	2
16.	Undertake Mock drill of students by using fire extinguisher for safety against fire	5	2*

Note:

- i. More Practical Exercises can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.

- ii. The following are some sample 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed Practical Exercises of this course required which are embedded in the COs and ultimately the competency.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1.	Set up / Connection of experimental	20
2.	Follow safe practices measures	10
3.	Perform specific operation on the equipment or Machines	20
4.	Record observations correctly if applicable	20
5.	Interpret the result and conclude	30

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED:

This following major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications
1.	Digital Multimeter: 4 ½ digit hand held 9 V batteries operated, DC Voltage: 0 to 0.001 mV – 1000 V, AC Voltage: 0 to 0.01 mV – 1000 V, AC Current: 0 to 100 nA – 10 A, DC Current: 0 to 100 nA – 10 A.
2.	Digital Tachometer: Hand held, battery operated, 5digit display contact Type, 60 to 50000 R.P.M.,
3.	Oil testing kit: Mains Supply: 230V AC $\pm 10\%$, 50Hz, Single Phase Variac: 230V/ 0-270V, High Voltage Source: 80kV, 20mA, Voltmeter: 0 to 100kV
4.	Megger: Insulation Testing: 250V:500V:1000V: 1000 M Ω range, Auto-ranging, Auto discharge
5.	Oil Testing kit: Power supply - 240V AC $\pm 10\%$, 50 Hz (single phase), with both fully Automated and manual operation, output range – 0 to 80 KV, output current – 20mA or may vary, resolution 0.1KV.

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded as per respective above-mentioned COs and PrOs. More could be supplemented to fulfil the development of this course competency.

- a. Develop skill for Installation of electrical equipments
- b. Develop skill for commissioning of electrical equipments
- c. Develop skill for maintenance of electrical equipments

- d. Develop skill for trouble shooting of distinct kind of faults in electrical equipments
- e. Follow safety practices while using electrical Machines and Equipments.
- f. Practice environment friendly methods and processes. (Environment related)

The ADOs are developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- a. 'Valuing Level' in 1st year
- b. 'Organization Level' in 2nd year
- c. 'Characterization Level' in 3rd year

8. UNDERPINNING THEORY:

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such COs could be included by the course teacher to focus on attainment of COs and competency.

Units	Major Learning outcomes	Topic and Sub-topics
Unit – I Installation of Electrical Equipment	<p>1a. Describe the planning before unloading of heavy electrical equipments at site</p> <p>1b. Select appropriate tools for installation of electrical equipment</p> <p>1c. Explain the procedure for handling, inspection, storage and installation of static and rotating electrical equipment as well as for Solar plant and wind plant</p>	<p>1.1 Unloading of electrical equipment at site</p> <p>1.2 Inspection of electrical equipment at site</p> <p>1.3 Storage electrical equipment at site</p> <p>1.4 Foundation electrical equipment at site</p> <p>1.5 Alignment of electrical machines</p> <p>1.6 Lists of Tools/Instruments required for installation</p> <p>1.7 Technical report, Inspection, storage & handling of transformer, switchgear & motors and Standard Field quality plan for installation of Power transformer, HT Motor and SF6 circuit breaker.</p> <p>1.8 Standard procedure for Installation of domestic and industrial Solar plant and wind plant</p>
Unit – II Commissioning and Testing	<p>2a. Describe various commissioning tests on electrical equipment/machines</p> <p>2b. Describe the specific test on electrical equipment/machines</p> <p>2c. Explain the standard tests performed on insulation oil</p> <p>2d. Determine the insulation resistance of electrical equipment/machines</p> <p>2e. Explain the procedure of</p>	<p>2.1 Tests before commissioning of electrical equipment-Electrical and Mechanical test, Preparations before commissioning of power transformer, Instruments required for testing</p> <p>2.2 Specific tests on -Transformer, Induction motor, alternator, synchronous motor</p> <p>2.3 Commissioning of power transformer, three phase induction motor and switchgear</p> <p>2.4 Transformer insulation oil: Properties as per IS, sampling, testing and filtering/purifying, standard tests as per IS, classification of insulation resistance</p> <p>2.5 Measurement of insulation resistance and</p>

	<p>drying the winding of electrical equipment/machines</p> <p>2f. Explain the various factor affecting the insulation resistance</p> <p>2g. Explain the need for gradual loading of electrical equipment</p> <p>2h. Commissioning and testing of GIS substation Installation.</p> <p>2i. Commissioning and testing of Solar plant and wind plant</p>	<p>Polarization Index, Factors affecting the insulation resistance of insulating materials</p> <p>2.6 Drying the winding of electrical equipment and its record</p> <p>2.7 Tests before and after commissioning of the Power transformer, Induction motor and HV circuit breaker</p> <p>2.8 Test report on commissioning and test certificate.</p> <p>2.9. Gradually loading of electrical equipment and Commissioning & testing of GIS substation Equipments</p> <p>2.10 Standard procedure for Commissioning of domestic and industrial Solar plant and wind plant.</p>
Unit – III Maintenance of Electrical Equipment	<p>3a. Explain the need of different types of maintenance</p> <p>3b. Explain the reason of failure of electrical equipment due to poor maintenance</p> <p>3c. Prepare maintenance schedule of different equipment</p> <p>3d. State the probable faults due to poor maintenance in various electrical equipment</p> <p>3e. Conditioning & monitoring of electrical equipment used in power system</p> <p>3f. Prepare Maintenance schedule of domestic and industrial Solar plant and wind plant and their core components</p>	<p>3.1 Need and functions of the Maintenance Department; Reasons of failure of electrical equipment</p> <p>3.2 Preventive maintenance: need, classification, activities, advantages and Frequency of maintenance</p> <p>3.3 Breakdown maintenance: concept, advantages, activities</p> <p>3.4 Factors for preparing maintenance schedule</p> <p>3.5 Maintenance schedule of transformer below and above 1000kVA</p> <p>3.6 Maintenance schedule - Induction motor, Alternator used in TPP and SF6 circuit Breaker</p> <p>3.7 Probable faults due to poor maintenance in transformer, induction motor, Alternator, circuit breaker, overhead lines, battery and solar plant inverter.</p> <p>3.8 Advantages of conditioning and monitoring of equipments</p> <p>3.9 Conditioning and monitoring of three phase Transformer and three phase Induction Motor</p> <p>3.10 Maintenance of domestic and industrial Solar plant and their core components and wind plant</p>
Unit – IV Troubleshooting Electrical equipments	<p>4a. State various internal and external faults that occur in electrical equipment</p> <p>4b. State common troubles in various electrical equipment and machines</p>	<p>4.1 Causes of faults in electrical equipment (Internal and external)</p> <p>4.2 Instruments and tools for trouble shooting</p> <p>4.3 Common troubles in electrical equipment – DC Machines, AC Machines, Transformers, Circuit-breaker, under-</p>

	<p>4c. Prepare trouble shooting chart for various electrical equipment, machines and domestic appliances.</p> <p>4d. State common causes of faults and their trouble shooting in domestic and industrial Solar Plant and wind plant</p>	<p>ground cable, electrical Installation</p> <p>4.4 Need of trouble shooting chart.</p> <p>4.5 Trouble shooting chart for DC Machine and both 1 Phase and 3 Phase Transformer.</p> <p>4.6 Trouble shooting chart for Synchronous Motor, Induction Motor and Alternator for thermal power plant.</p> <p>4.7 Trouble shooting chart for SF6 Circuit-breaker and Vacuum Circuit-breaker.</p> <p>4.8 Trouble shooting chart for Domestic appliances-electrical iron, ceiling fan, washing machine, Air cooler</p> <p>4.9 Common causes of faults and their trouble shooting in domestic and industrial Solar Plant and wind plant</p>
<p>Unit – V Electrical Accidents Safety</p> <p>&</p>	<p>5a. Explain the major causes of electrical accidents and their consequences</p> <p>5b. Explain the need of earthing and the different methods of earthing</p> <p>5c. Explain the various factors affecting on the earth resistance</p> <p>5d. Describe the various methods of measuring the earth resistance</p> <p>5e. Explain the earthing procedure in different types of electrical installations</p> <p>5f. Describe the procedure for shutting down of substation and power lines</p> <p>5g. Explain the operation of different types of fire extinguishers</p>	<p>5.1 Major causes of electrical accidents</p> <p>5.2 Consequences of electrical accidents, factors affecting the severity of electrical shock and Preventive steps against electrical accidents</p> <p>5.3 Necessity of earthing, various factors affecting on the earth resistance, advantages and types of earth electrodes</p> <p>5.4 Methods of earthing: plate earthing, pipe earthing and coil earthing and Chemical Earthing</p> <p>5.5 Measurement of earth resistance: voltmeter-ammeter method, earth tester method, ohm meter method and earth loop tester method</p> <p>5.6 Earthing procedure - Building installation, Domestic appliances, Industrial premises, earthing of substation, generating station and overhead line</p> <p>5.7 Describe the procedure for shutting down of substation and Certificate of (i) requisition for shut down (ii) Permit to work and (iii) Line clear certificate</p> <p>5.8 Fire Extinguishers-Fixed installation and portable devices</p>

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN:

Sr. No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1.	Installation of Electrical Equipment	08	7	3	4	14
2.	Commissioning and Testing	10	3	4	7	14
3.	Maintenance of Electrical Equipment	10	4	3	7	14
4.	Trouble Shooting of Electrical Equipment	08	3	4	7	14
5.	Electrical Accidents & Safety	06	4	7	3	14
Total		42	21	21	28	70

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the COs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly 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 performed to meliorate the attainment of the various outcomes of the course: Students should perform following activities individually or in group to accomplish distinct task and prepare reports of about min 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement:

Followings are the list of proposed student activities such as:

- I. Prepare journals based on practical performed in laboratory
- II. Enlist latest equipment and tools used for the commissioning of the machines and equipments
- III. Solving numerical from different books for practice
- IV. List various instruments and tools used for troubleshooting
- V. Explore latest trouble shooting techniques and steps to troubleshoot various electrical equipments and machines by expert lecture, webinar and Industrial visits
- VI. Prepare trouble shooting chart for various electrical equipments
- VII. Inspect all the earthing point within college campus and measure their values
- VIII. Site visit for installation, commissioning and testing of Transformer/Rotating AC machine

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

This is as

- I. Show video/animation film to demonstrate earthing, grounding

- II. Arrange a visit to nearby industry/substation to observe installation/commissioning and troubleshooting of various electrical equipment and machines.
- III. Use Flash/Animations to demonstrate installation of various electrical equipment and devices.
- IV. Arrange expert lectures of the professional engineers involved in installation, commissioning and testing of heavy power equipments/machines.
- V. Allocate Mini projects to students

12. SUGGESTED MICRO-PROJECT LIST:

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. However, in the fifth and sixth semesters, microproject should preferably be assigned **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 & COs. 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 duration of the microproject should be about 14-16 (fourteen to sixteen) student engagement hours during the course. The students 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. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

Sr. No.	Projects
1.	Prepare chart of planning for inspection of any of electrical machines / Equipments. (Existing in your laboratory)
2.	Enlist necessary tools and Instruments used for Installation of electrical machines / Equipments
3.	Enlist commissioning test to be carried out on any of electrical machines / Equipments
4.	Prepare report on tests conducted on Insulating oil in laboratory.
5.	Prepare chart for maintenance schedule of solar roof top installed at your institute premises.
6.	Prepare chart for maintenance schedule of UPS set installed within your institute premises.
7.	Enlist the common probable faults occurring in the any of electrical machines / Equipments.
8.	Prepare causes of faults along with their trouble shooting chart for any of electrical machines / Equipments
9.	Prepare chart with neat diagram for any of earthing methods along its significance
10.	Prepare report of earthing resistance of each earth points existing within college campus.
11.	Prepare maintenance schedule for both domestic and industrial solar plants.
12.	Prepare maintenance schedule for wind plant.
13.	Prepare charts or PPT for causes of electrical accidents.

Note: ‘Any’ stands for name of particular electrical machine or equipment

13. SUGGESTED LEARNING RESOURCES:

Sr. No.	Title of Book	Author	Publication
1.	Installation Maintenance and Repair of Electrical Machines and Equipments	Madhvi Gupta	S.K. Kataria & Sons, New Delhi
2.	Electrical Workshop Safety Commissioning Maintenance & Testing of Electrical Equipment	R. P. Singh	Dreamtech Press
3.	Installation, Commissioning and Maintenance of Electrical equipment	Tarlok Singh	S. K. Kataria & Sons, New Delhi
4.	Testing Commissioning Operation and Maintenance of Electrical Equipments	S. Rao	Khanna Publication, New Delhi
5.	Electrical Power System	C. L. Wadhwa	New Age International Publications, New Delhi
6.	Residential, Commercial and Industrial Electrical Systems: Protection, Testing and Commissioning	Hemant Joshi	Dreamtech Press

14. SOFTWARE/LEARNING WEBSITES

1. <http://cercind.gov.in/ElectSupplyAct1948.pdf>
2. https://cea.nic.in/wp-content/uploads/pse___td/2021/09/Transformer_Manual__Amendment_01.pdf
3. <https://www.youtube.com/live/-G9sv557tNk?si=aKuyqRZiaKwD8J5a>
4. <https://youtu.be/CvuDFgFFOa8?si=H-v3LZMygCdeotoM>
5. <https://youtu.be/KOH1TVf1EuY?si=qDJ5iHytJnSJkZyI>
6. https://www.getcogujarat.com/getco_news/site/files/safetypolicy.pdf

15. PO-COMPETENCY-CO MAPPING:

Semester VI	Electrical Installation, Commissioning and Maintenance (Course Code:4360901)						
	POs						
Competency & Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7
Undertake Installation, Commissioning and Maintenance of various power system components and equipment.							
CO1: Install various electrical equipments/machines.	3			2	2	2	2
CO2: Commission & Test various electrical equipments/machines	3	2	2	3	2	1	
CO3: Carryout maintenance of different electrical equipments and machines.	2	2		3	2		2
CO4: Troubleshoot for various electrical equipments/machines and domestic electrical appliances.	3	2	2	3			2
CO5: Apply safety rules, safety practices and electrical earthing.	2			2	3	2	3

Abbreviation: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE**GTU Resource Persons:**

Sr. No.	Name and Designation	Institute	Contact No.	Email
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