02-12-2025 12:01:57 PM

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Programme Name/s : **Electrical Engineering/ Electrical Power System**
Programme Code : **EE/ EP**
Semester : **Sixth**
Course Title : **MAINTENANCE OF ELECTRICAL EQUIPMENTS**
Course Code : **316328**

I. RATIONALE

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

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences: Maintain different types of electrical equipment following safe practices.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Follow safety norms to prevent accidents while using electrical equipment.
- CO2 - Test electrical equipment.
- CO3 - Maintain rotating electrical machines.
- CO4 - Maintain single phase and three phase transformers.
- CO5 - Maintain insulation systems of electrical equipment.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316328	MAINTENANCE OF ELECTRICAL EQUIPMENTS	MEE	DSC	4	-	4	2	10	5	3	30	70	100	40	25	10	25#	10	25	10	175

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain the hazards, safety actions for the given situation. TLO 1.2 Explain the importance of accident prevention. TLO 1.3 Describe the responsibilities and the monitoring actions of the supervisor in the given hazardous or accident situation. TLO 1.4 Describe the operating procedural steps of the given types of fire extinguishers. TLO 1.5 State the principle characteristics and related precautions for safety of equipment earthed by the specified clause. TLO 1.6 State the reasons behind failure of the given electrical equipment. TLO 1.7 State the role of Bureau of Indian Standards in testing, importance of ISI mark in testing and maintenance of electrical equipment.	**Unit - I Safety and prevention of accidents** 1.1 Hazards, accidents, safety 1.2 Dos and Don’ts for electrical supervisors. 1.3 Electric shock: factors influencing severity of shock, rescuing a person from electric shock, different CPR Technique to employed under accidental condition. 1.4 Artificial respiration: types & procedures. 1.5 Precautions against electric fire. 1.6 Types of fire extinguishers, “PASS” & “RACE” in case of fire. 1.7 Objectives of earthing. Earthing of electrical equipment as per IS 3043-1987 1.8 Protection of electrical equipment against electric shock (class 0 to class III). 1.9 Causes of failure of electrical Equipment: internal and external 1.10 Role of BIS in testing of electrical Equipment.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Case Study Collaborative learning Hands-on Site/Industry Visit

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Explain the objectives of the testing. TLO 2.2 Describe the procedure of the given testing methods. TLO 2.3 Explain the importance of the given categories of tests. TLO 2.4 Explain the importance of tolerance. TLO 2.5 Explain meaning and importance of ingress protection. TLO 2.6 Explain significance of maintenance of electrical equipment. TLO 2.7 State the given type(s) of maintenance technique. TLO 2.8 Explain the given factor(s) affecting preventive maintenance. TLO 2.9 Describe the procedures for developing preventive maintenance schedule. TLO 2.10 Explain the steps in preparing foundation for the given type of rotating machine. TLO 2.11 Suggest tools for maintenance of the given rotating machine.	**Unit - II Testing and Maintenance** 2.1 Objectives of testing. 2.2 Methods of testing : direct, indirect and regenerative. 2.3 Categories of Tests: routine, type, special and supplementary tests. 2.4 Tolerance. 2.5 Ingress protection, IP marking. 2.6 Significance of maintenance of electrical equipment. 2.7 Types of maintenance-routine, preventive, breakdown maintenance. 2.8 Factors affecting the preventive maintenance schedule. 2.9 Procedure for developing preventive maintenance schedule. 2.10 Foundations: requirements and factors affecting rotating machine foundation. 2.11 Tools/instruments: bearing puller, filler gauge, dial indicator, spirit level, megger, earth tester, growler, test lamps, multimeter, spanner sets, and screwdrivers.	Lecture Using Chalk-Board Presentations Video Demonstrations Model Demonstration Flipped Classroom Collaborative learning Case Study
3	TLO 3.1 Describe the procedural steps to be followed as per IS code of practice for maintenance of the given machine. TLO 3.2 Describe the procedural steps to be followed as per IS code of practice for testing of the given induction motor. TLO 3.3 Describe the procedural steps to be followed as per IS code of practice for testing of the given three - phase alternator and synchronous motor. TLO 3.4 Prepare the trouble shooting chart for the given type of induction motor.	**Unit - III Procedure for developing preventive maintenance schedule of Rotating Machines** 3.1 Recommended maintenance schedules: Single phase and three phase induction motors (IS 900 – 1992), three phase alternators and synchronous motors. 3.2 Induction motor testing: Routine, type and special test of single phase induction motor as per IS 7572 – 1974 and three phase induction motor as per IS4029 -2010. 3.3 Alternator and synchronous motor testing: Routine, type and special test of three phase alternator and synchronous motor as per IS 7132-1973. 3.4 Trouble shooting chart for single phase and three phase induction motor (IS 900 – 1992).	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Collaborative learning Case Study Site/Industry Visit

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Describe the procedural steps to be followed as per IS code of practice for maintenance of the given transformer. TLO 4.2 Explain the specified test with its purpose and identify the terminals of a given type of transformer. TLO 4.3 Describe the procedural steps to be followed for finding voltage ratio of given transformer by various methods. TLO 4.4 Describe the Polarity test, Phasing out test, Back to Back test of given transformer. TLO 4.5 Prepare the trouble shooting chart for single phase and three phase transformers. TLO 4.6 Suggest the foundation requirement with sketch for the given type of transformer.	**Unit - IV Testing and trouble shooting of transformers** 4.1 Recommended maintenance schedules: transformers (IS 10028, part III – 1981) 4.2 Routine, type, supplementary, special tests of transformers, nomenclature of transformer terminals as per IS 2026-1981. 4.3 Measurement of voltage ratio by ratio meter, standard transformer, turn testing method. 4.4 Polarity test. 4.5 Phasing out test. 4.6 Back to Back test. 4.7 Trouble-shooting chart for single phase and three phase transformers. 4.8 Foundations: requirements for static machine foundations, factors governing them as per IS 10028 part 2.	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Collaborative learning Site/Industry Visit Case Study
5	TLO 5.1 Classify the insulation material for electrical equipment as per IS code of practice. TLO 5.2 State the factors affecting the life of insulating material. TLO 5.3 Describe the procedural steps to be adopted for measurement of insulation resistance by different methods. TLO 5.4 State the different properties and contaminating agents of transformer oil. TLO 5.5 Describe the procedural steps to be followed as per IS code of practice for testing of transformer oil. TLO 5.6 Describe the various methods of purification, cleaning of transformer oil and drying and re-varnishing of transformer windings. TLO 5.7 Prepare the sample history sheet for the specified electrical machine.	**Unit - V Testing and reconditioning of electrical machine insulation** 5.1 Classification of insulating materials as per IS 8504- 1994. 5.2 Factors affecting life of insulating materials. 5.3 Measurement of insulation resistance by megger, voltmeter, dielectric absorption, polarisation index. 5.4 Transformer oil: properties, contaminating agents. 5.5 Testing of transformer oil as per IS 1866 : Dielectric strength test, acidity test, sludge test, crackle test, flashpoint and fire point test. 5.6 Reconditioning of insulation: centrifugal purifiers, streamline filter (Vacuum type) for purification and filtering of insulating oil. Cleaning and drying, re-varnishing, construction and working of vacuum Impregnation plant. 5.7 History sheets of transformers and induction motors: [Part A: machine specifications with component specifications (installation information, bearings, oil type, core weight etc. as applicable); Part B: date wise: observations of parameters such as voltage, current, temperature etc., symptoms, works carried out under maintenance).	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom Collaborative learning Case Study

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use fire extinguishers to extinguish the fire.	1	* Demonstration of Fire extinguisher available in the institute.	2	CO1
LLO 2.1 Apply artificial respiration in case of emergency.	2	* Demonstration of artificial respiration (Any convenient method).	2	CO1
LLO 3.1 Measure earth resistance.	3	* Measurement of earth resistance of electrical laboratory equipment.	2	CO1
LLO 4.1 Identify protective class of a given electric equipment.	4	*Protective class of a given electric equipment.	2	CO1
LLO 5.1 Get acquainted with the procedure for getting ISI mark.	5	* Visit BIS portal (bis.gov.in) for getting ISI mark/obtaining a license for electrical equipments and prepare a report for it.	4	CO1
LLO 6.1 Use tools/accessories applicable in the process. LLO 6.2 Identify the parts of a given motor.	6	* Dismantle and reassemble the given electrical machine and identify the various parts.	2	CO2
LLO 7.1 Use testing instrument for testing electrical equipment.	7	* Use of instruments for testing/maintenance of given electrical equipment.	2	CO2
LLO 8.1 Test given LED for ingress of water to confirm the IP rating.	8	* Testing of given 70 W or higher rating LED for ingress of water to confirm the IP rating	2	CO2
LLO 9.1 Carryout maintenance activities suggested in IS: 900-1992(Annex G) at 5,6,7 and 8 for maintenance of induction motors.	9	Maintainance of given induction motor.	2	CO3
LLO 10.1 Carryout maintenance activities suggested in IS: 10028- part 3 at 1,2,3 and 4for maintenance of transformer.	10	Maintainance of given transformer.	2	CO4
LLO 11.1 Identify the parts of single-phase induction motor. LLO 11.2 Rectify the basic faults in given single phase induction motor	11	Diagnosis and rectification of faults for a ceiling fan running slow.	1	CO3
LLO 12.1 Identify the parts of single-phase induction motor. LLO 12.2 Rectify the basic faults in given single phase induction motor.	12	Diagnosis and rectification of faults for a ceiling fan running in reverse direction.	2	CO3
LLO 13.1 Test the insulation condition of single-phase induction motor (before and after no load running)	13	Measurement of winding resistance of a single-phase induction motor by V-I method.	2	CO3
LLO 14.1 Test the three phase induction motor before commissioning.	14	* Reduced voltage running up test of three phase induction motor	2	CO3
LLO 15.1 Test the insulation condition of three phase induction motor (before and after no load running).	15	Measurement of phase winding resistance of a three-phase induction motor by V-I method.	2	CO3
LLO 16.1 Test the insulation condition of three phase induction motor (before and after conducting brake test).	16	Measurement of phase winding resistance of a three-phase induction motor by V-I method.	2	CO3
LLO 17.1 Identify primary and relevant secondary windings of transformer.	17	* Phasing out test of the three-phase transformer.	2	CO4
LLO 18.1 Identify the polarity of transformer windings.	18	* Polarity test of three phase transformer.	2	CO4

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 19.1 Apply regenerative method of testing.	19	Back-to-Back test on two identical single-phase transformers.	2	CO4
LLO 20.1 Test the dielectric strength of transformer oil. LLO 20.2 Using transformer testing oil kit.	20	Dielectric strength test of transformer oil.	2	CO5
LLO 21.1 Insulation resistance and dielectric strength of the windings in a single-phase induction motor applying high-voltage, ensuring that the motor can withstand operational voltage without failure	21	Test insulation resistance and dielectric strength of the windings of a single-phase induction motor.	2	CO5
LLO 22.1 Insulation resistance and dielectric strength of the windings in a three-phase induction motor by applying high-voltage, ensuring that the motor can withstand operational voltage without failure	22	Test insulation resistance and dielectric strength of the windings of a three-phase induction motor.	2	CO5
LLO 23.1 Measure insulation resistance of single-phase induction motor.	23	Measurement of insulation resistance of single-phase induction motor.	2	CO5
LLO 24.1 Measure insulation resistance of three phase induction motor.	24	Measurement of insulation resistance of three phase induction motor.	2	CO5
LLO 25.1 Measure insulation resistance of single phase transformer.	25	Measurement of insulation resistance of single-phase transformer.	2	CO5
LLO 26.1 Measure insulation resistance of three phase transformer.	26	Measurement of insulation resistance of three phase transformer.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

SUGGESTED STUDENT ACTIVITIES

- Prepare report for step-by-step procedure to be followed for artificial respiration to be given to shock affected person.
- Prepare power point presentation on testing of Induction motor as per IS.
- Prepare power point presentation related to foundation of transformers.
- Collect sample of various class of insulating materials and prepare a chart of it.
- Prepare report for step-by-step procedure to be followed for VFD maintenance.

Assignment

- Elaborate various cooling methods of alternator.
- Prepare excel sheet for carrying out preventive maintenance schedule on any machine in lab.
- Elaborate Cable insulation HV test and cable conductor resistance measurement test using LCR meter.
- Collect information and prepare report on MSEDCL transformer maintenance.
- Elaborate various motor winding temperature measurement methods.
- Elaborate various transformer cooling methods.

Micro project

- Collect information on safety signs used for electrically hazardous areas and prepare charts for display in the laboratory or work place.
- Collect information on CPR Technique and prepare charts for display in the laboratory or work place.

- Visit electrical machine manufacturing unit and collect data of various tests conducted on it and submit a detailed report.
- Prepare a report on diagnosis of transformer oil sample by conducting various tests on it and submit a detailed report.
- Collect information of specifications, uses, cost of various tools and equipment needed for carry out maintenance of different electrical machines submit a detailed report.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Fire extinguisher (powder type)	1
2	400V/230V, 50 Hz, 3-phase transformer with all phase winding terminals brought out for connections (suitable output in range of 2 kVA to 4 kVA).	10
3	Ceiling fan	11,12
4	AC-DC Ammeter range (0-2.5-5-10A) .	15,16,14
5	AC-DC Voltmeter Range (0-75/150/300V, 0 - 300V /600 V)	15,16,14
6	Single phase auto transformer 0-270 V, 15 A, input single phase, 230 V.	17,18,19
7	Three phase auto transformer 0-450 V, 15 A, input 3 phase, 400 V.	17,18,19
8	At least two identical 230 V/115 V or 400 V/ 230 V 50 Hz, 1 or 2 kVA single phase transformers.	18
9	Dielectric oil testing kit (with input at 230 V).	20
10	HV test kits for motors up-to 400 V.	21,22
11	Earth Resistance tester	3
12	230 V, 50 Hz, single phase capacitor start cage type induction motor (suitable available HP)	6,9
13	3-phase 5 HP, 400 V, 50 Hz, 1500 RPM squirrel cage induction motor with brake load arrangement as required.	6,9
14	Bearing puller, filler gauge, dial indicator, spirit level, megger, earth tester, growler, test lamps, multimeter, spanner sets, and screwdrivers.	7
15	LED lamp (70 W or higher rating)	8
16	3-phase 400V, 50 Hz, 1500 RPM slip ring induction motor about 5 HP.	9
17	Tachometers 0-5000 RPM minimum.	9,11,12,21,22
18	A.C. Watt meters: 0-300/600 V, 5/10 A or 10/20 A as needed.	9,11,12,21,22
19	LPF Wattmeter, 0-300/600 V, 1A to 2A.	9,11,12,21,22

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Safety and prevention of accidents	CO1	8	2	4	4	10

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
2	II	Testing and Maintenance	CO2	18	4	6	10	20
3	III	Procedure for developing preventive maintenance schedule of Rotating Machines	CO3	8	2	4	4	10
4	IV	Testing and trouble shooting of transformers	CO4	18	4	4	12	20
5	V	Testing and reconditioning of electrical machine insulation	CO5	8	2	2	6	10
Grand Total				**60**	**14**	**20**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment.
- Two unit tests of 30 marks will be conducted and an average of two unit tests considered.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	3	2	3	3	-	3			
CO2	3	3	2	3	2	2	3			
CO3	3	3	2	3	2	2	3			
CO4	3	3	2	3	2	2	3			
CO5	3	3	2	3	2	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Bhattacharya S. K.	Electrical Machines	McGraw Hill Education. New Delhi, ISBN : 9789332902855
2	Theraja B.L.	Electrical Technology Vol-II (AC and DC machines)	S.Chand and Co.Ltd., New Delhi ISBN : 9788121924375
3	Bandyopadhyay M. N.	Electrical Machines Theory and Practice	PHI Learning Pvt. Ltd., New Delhi, ISBN :9788120329973 VI

MAINTENANCE OF ELECTRICAL EQUIPMENTS **Course Code : 316328**

Sr.No	Author	Title	Publisher with ISBN Number
4	Jean-Claude Trigeassous	Electrical Machine Diagnosis	John Wiley & Sons, IncISBN:978-1-84821-263-3.

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=w4jHpHoYZhk	How to Use a Fire Extinguisher
2	https://www.youtube.com/watch?v=wrawEAaJrrY	Artificial respiration methods
3	https://www.youtube.com/watch?v=CvuDFgFFOa8	Fundamentals of Transformer Commissioning and Maintenance Testing
4	https://www.youtube.com/watch?v=ntOc4h792UE	Motor Maintenance & Troubleshooting
5	https://www.youtube.com/watch?v=uMxK6djp_rI	Electric Motor Repair & Rebuild Instructions
6	https://youtu.be/JvsPnGbUH5M	power transformer oil filtration and treatment
7	https://nptel.ac.in/	Relevant information from NPTEL
8	https://www.electricaltechnology.org/	Relevant information
9	https://www.electrical4u.com/	Relevant information

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

MSBTE Approval Dt. 04/09/2025 **Semester - 6, K Scheme**