

**Date: 15 /12 /2025**

**Institute Name & Code:** K. K. Wagh Polytechnic, Nashik (0078)

**Program and Code:** Electrical Engineering (EE)

**Course Index:** C604

**Course Name:** Maintenance of Electrical Equipment

**Course Code:** 316328

**Semester:** VI<sup>th</sup> **Scheme:** 'K' **Allocated Hrs:** 60

**Name of Faculty:** Mr.J.M.Patil

**Class:** TYEE (Tesla)

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● **Teaching and Examination Scheme:**

<b>Total IKS Hrs for Sem. : 0 Hrs</b>	
<b>Abbreviations:</b> 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	
<b>Legends:</b> @ Internal Assessment, # External Assessment, *# On Line Examination , @\$ Internal Online Examination	
<b>Note :</b>	
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.	

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme						Credits	Assessment Scheme												Total Marks
				Actual Contact Hrs./Week			SLH	NLH	Paper Duration		Theory				Based on LL & TL				Based on SL				
															Practical				SLA				
				CL	TL	LL	FA-TH	SA-TH			Total		FA-PR		SA-PR		SLA						
				Max	Max	Max	Min	Max	Min	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		

● **Course Objectives:**

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.

**Course Outcomes (COs) and Unit Outcomes: Theory & Practical**

By learning course Maintenance of Electrical Equipment (MEE-316328), Third Year students will be able to:

## 1. Theory Learning Outcome:

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.		
1	<p>TLO 1.1 Explain the hazards, safety actions for the given situation.</p> <p>TLO 1.2 Explain the importance of accident prevention.</p> <p>TLO 1.3 Describe the responsibilities and the monitoring actions of the supervisor in the given hazardous or accident situation.</p> <p>TLO 1.4 Describe the operating procedural steps of the given types of fire extinguishers.</p> <p>TLO 1.5 State the principle characteristics and related precautions for safety of equipment earthed by the specified clause.</p> <p>TLO 1.6 State the reasons behind failure of the given electrical equipment.</p> <p>TLO 1.7 State the role of Bureau of Indian Standards in testing, importance of ISI mark in testing and maintenance of electrical equipment.</p>	2	<p>TLO 2.1 Explain the objectives of the testing.</p> <p>TLO 2.2 Describe the procedure of the given testing methods.</p> <p>TLO 2.3 Explain the importance of the given categories of tests.</p> <p>TLO 2.4 Explain the importance of tolerance.</p> <p>TLO 2.5 Explain meaning and importance of ingress protection.</p> <p>TLO 2.6 Explain significance of maintenance of electrical equipment.</p> <p>TLO 2.7 State the given type(s) of maintenance technique.</p> <p>TLO 2.8 Explain the given factor(s) affecting preventive maintenance.</p> <p>TLO 2.9 Describe the procedures for developing preventive maintenance schedule.</p> <p>TLO 2.10 Explain the steps in preparing foundation for the given type of rotating machine.</p> <p>TLO 2.11 Suggest tools for maintenance of the given rotating machine.</p>	3	<p>TLO 3.1 Describe the procedural steps to be followed as per IS code of practice for maintenance of the given machine.</p> <p>TLO 3.2 Describe the procedural steps to be followed as per IS code of practice for testing of the given induction motor.</p> <p>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.</p> <p>TLO 3.4 Prepare the trouble shooting chart for the given type of induction motor.</p>

Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	
4	<p>TLO 4.1 Describe the procedural steps to be followed as per IS code of practice for maintenance of the given transformer.</p> <p>TLO 4.2 Explain the specified test with its purpose and identify the terminals of a given type of transformer.</p> <p>TLO 4.3 Describe the procedural steps to be followed for finding voltage ratio of given transformer by various methods.</p> <p>TLO 4.4 Describe the Polarity test, Phasing out test, Back to Back test of given transformer.</p> <p>TLO 4.5 Prepare the trouble shooting chart for single phase and three phase transformers.</p> <p>TLO 4.6 Suggest the foundation requirement with sketch for the given type of transformer.</p>	5
		<p>TLO 5.1 Classify the insulation material for electrical equipment as per IS code of practice.</p> <p>TLO 5.2 State the factors affecting the life of insulating material.</p> <p>TLO 5.3 Describe the procedural steps to be adopted for measurement of insulation resistance by different methods.</p> <p>TLO 5.4 State the different properties and contaminating agents of transformer oil.</p> <p>TLO 5.5 Describe the procedural steps to be followed as per IS code of practice for testing of transformer oil.</p> <p>TLO 5.6 Describe the various methods of purification, cleaning of transformer oil and drying and re-varnishing of transformer windings.</p> <p>TLO 5.7 Prepare the sample history sheet for the specified electrical machine.</p>

## 2. Laboratory Learning Outcome:

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Relevant COs
LLO 1.1 Use fire extinguishers to extinguish the fire.	CO1

LLO 2.1 Apply artificial respiration in case of emergency.	CO1
LLO 3.1 Measure earth resistance.	CO1
LLO 4.1 Identify protective class of a given electric equipment.	CO1
LLO 5.1 Get acquainted with the procedure for getting ISI mark.	CO1
LLO 6.1 Use tools/accessories applicable in the process.	CO2
LLO 6.2 Identify the parts of a given motor.	
LLO 7.1 Use testing instrument for testing electrical equipment.	CO2
LLO 8.1 Test given LED for ingress of water to confirm the IP rating.	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.	CO3
LLO 10.1 Carryout maintenance activities suggested in IS: 10028- part 3 at 1,2,3 and 4for maintenance of transformer.	CO4
LLO 11.1 Identify the parts of single-phase induction motor.	CO3
LLO 11.2 Rectify the basic faults in given single phase induction motor	
LLO 12.1 Identify the parts of single-phase induction motor.	CO3
LLO 12.2 Rectify the basic faults in given single Phase induction motor.	
LLO 13.1 Test the insulation condition of single- phase induction motor (before and after no load running)	CO3
LLO 14.1 Test the three phase induction motor before commissioning.	CO3
LLO 15.1 Test the insulation condition of three phase induction motor (before and after no load running).	CO3
LLO 16.1 Test the insulation condition of three phase induction motor (before and after conducting brake test).	CO3
LLO 17.1 Identify primary and relevant secondary windings of transformer.	CO4
LLO 18.1 Identify the polarity of transformer windings.	CO4
LLO 19.1 Apply regenerative method of testing.	CO4
LLO 20.1 Test the dielectric strength of transformer oil.	CO5
LLO 20.2 Using transformer testing oil kit.	
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	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	CO5
LLO 23.1 Measure insulation resistance of single-phase induction motor.	CO5
LLO 24.1 Measure insulation resistance of three phase induction motor.	CO5
LLO 25.1 Measure insulation resistance of single phase transformer.	CO5
LLO 26.1 Measure insulation resistance of three phase transformer.	CO5

• Teaching Plan:

Unit No. (Allotted Hrs.)	Teaching Learning Outcome	Title/Topic Details and Course Outcome (CO)	Plan (From-To & No. of Lectures)	Actual Execution (From-To & No. of Lectures)	Teaching Method/ Media/ Tools	Remark
01. (8)	TLO 1.1 1.2	<b>Safety and prevention of accidents [CO604.1]</b> 1.1 Safety practices: safety, hazards, accidents, dos and don'ts for substation operators	15/12/2025 To 19/12/2025		PPT, Black Board, YouTube Videos	



	1.3	1.2 Electric shock: factors influencing severity of shock, rescuing persons, procedures for artificial respiration	(03)			
	TLO 1.4 1.5	1.3 Precautions against electric fires, use of fire extinguishers, actions in case of such fires, Types of fire extinguishers, “PASS” & “RACE” in case of fire.	20/12/2025 To 25/12/2025 (03)		PPT, Black Board, YouTube Videos	
	TLO 1.5 1.6 1.7	1.4 Earthing of electrical equipment {refer IS code IS 3043 – 1987): Objectives, classification of electrical equipment with regard to protection against electric shock: Class 0 to III 1.5 Role of BIS in testing of electrical Equipment.	26/12/2025 To 27/12/2025 (02)		PPT, Black Board, YouTube Videos	
<b>02. (18)</b>	TLO 2.1 2.2	<b>Testing and Maintenance [CO604.2]</b> 2.1 Objectives of testing. 2.2 Methods of testing : direct, indirect and regenerative.	01/01/2026 To 05/01/2026 (04)		PPT, Black Board, YouTube Videos	
	TLO 2.3 2.4 2.5	2.3 Categories of Tests: routine, type, special and supplementary tests. 2.4 Tolerance. 2.5 Ingress protection, IP marking.	08/01/2026 To 10/01/2026 (03)		PPT, Black Board, YouTube Videos	
	TLO 2.6 2.7	2.6 Significance of maintenance of electrical equipment. 2.7 Types of maintenance-routine, preventive, breakdown maintenance.	12/01/2026 To 15/01/2026 (02)			
	TLO 2.8 2.9	2.8 Factors affecting the preventive maintenance schedule. 2.9 Procedure for developing preventive maintenance schedule.	16/01/2026 To 22/01/2026 (04)			
	TLO 2.10	2.10 Foundations: requirements and factors affecting rotating machine foundation.	23/01/2026 To 30/01/2026 (03)			
	TLO 2.11	2.11 Tools/instruments: bearing puller, filler gauge, dial indicator, spirit level, megger, earth tester, growler, test lamps, multimeter, spanner sets, and screwdrivers.	31/01/2026 To 02/02/2026 (02)			
<b>03. (08)</b>	TLO 3.1	<b>Procedure for developing preventive maintenance schedule of Rotating Machines [CO604.3]</b> 3.1 Recommended maintenance schedules: Single phase and three phase induction motors (IS 900 – 1992), three phase alternators and synchronous motors	05/02/2026 to 06/02/2026 (02)		PPT, Black Board, YouTube Videos	
	TLO 3.2	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.	07/02/2026 to 13/02/2026 (04)		PPT, Black Board, YouTube Videos	
	TLO 3.3	3.3 Alternator and synchronous motor testing: Routine, type and special test of three phase alternator and synchronous motor as per IS 7132-1973.	14/02/2026 to 14/02/2026 (01)		PPT, Black Board, YouTube Videos	
	TLO 3.4	3.4 Trouble shooting chart for single phase and three phase induction motor (IS 900 – 1992).	16/02/2026 to 16/02/2026 (01)		PPT, Black Board, YouTube Videos	
<b>04. (18)</b>	TLO 4.1	<b>Maintain single phase and three phase transformer.(CO604.4)</b> 4.1Recommended maintenance schedules: transformers (IS 10028, part III – 1981)	19/02/2026 to 20/02/2026 (02)		PPT, Black Board, YouTube Videos	

	TLO 4.2	4.2 Routine, type, supplementary, special tests of transformers, nomenclature of transformer terminals as per IS 2026-1981.	21/02/2026 to 21/02/2026 (02)		PPT, Black Board, YouTube Videos	
	TLO 4.3	4.3 Measurement of voltage ratio by ratio meter, standard transformer, turn testing method.	23/02/2026 to 26/02/2026 (02)		PPT, Black Board, YouTube Videos	
	TLO 4.4	4.4 Polarity test.	26/02/2026 to 06/03/2026 (06)		PPT, Black Board, YouTube Videos	
		4.5 Phasing out test.				
		4.6 Back to Back test.				
	TLO 4.5	4.7 Trouble-shooting chart for single phase and three phase transformers.	07/03/2026 To 12/03/2026 (03)		PPT, Black Board, YouTube Videos	
	TLO 4.6	4.8 Foundations: requirements for static machine foundations, factors governing them as per IS 10028 part 2.	13/03/2026 To 16/03/2026 (03)			
<b>05. (08)</b>	TLO 5.1	<b>Testing and reconditioning of electrical machine insulation [CO604.5]</b>			PPT, Black Board, YouTube Videos	
		5.1 Classification of insulating materials as per IS 8504-1994.	19/03/2026 To 20/03/2026 (02)			
	5.2	5.2 Factors affecting life of insulating materials.				
	TLO 5.3	5.3 Measurement of insulation resistance by megger, voltmeter, dielectric absorption, polarisation index.	21/03/2026 To 21/03/2026 (01)		PPT, Black Board, YouTube Videos	
	*BS	5.3.1 Interpretation of condition of insulation	22/03/2026 To 22/03/2026 (01)			
	TLO 5.4	5.4 Transformer oil: properties, contaminating agents.	23/03/2026 To 23/03/2026 (01)		PPT, Black Board, YouTube Videos	
	5.5	5.5 Testing of transformer oil as per IS 1866 : Dielectric strength test, acidity test, sludge test, crackle test, flashpoint and fire point test.				
	TLO 5.6	5.6 Strengthening insulations: weakening agents, cleaning, drying, re-varnishing, baking, impregnation, and filtration.	26/03/2026 To 27/03/2026 (02)		PPT, Black Board, YouTube Videos	
	TLO 5.6	5.6 Measure to be taken to maintain the insulation resistance of electrical machines to healthy levels.	28/03/2026 To 28/03/2026 (01)		PPT, Black Board, YouTube Videos	
	TLO 5.7	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 observation of parameters such as voltage, current, temperature etc., symptoms, work carried out under maintenance.	30/03/2026 To 30/03/2026 (01)		PPT, Black Board, YouTube Videos	
		Total	60			

**\*BS: Additional topic conducted considering beyond syllabus coverage:** Contents of beyond Syllabus (Additional Topic) imparted for the attainment of the COs/POs & fulfill the Course gap.

- Chapter wise CO Mapping:

	CO604.1	CO604.2	CO604.3	CO604.4	CO604.5
Chapter 1	✓	✓	✓	✓	✓
Chapter 2		✓			
Chapter 3			✓		
Chapter 4				✓	
Chapter 5					✓

### o Direct Assessment Criteria:

- Rules for Theory Assessment:**

- Unit wise Offline test out of 30 marks will be conducted after completion of each unit.
- Assignment on each unit will be given to the students after completion of Unit; students have to upload the solved assignment on Google Classroom/submit the same to teacher.
- Total weightage of Theory Marks to the Course is 100. From 100 Marks 70 Marks are allotted to MSBTE TH Examination and 30 Marks are allotted to Formative Assessment (FR TH) for which Two Class tests of 30 marks each will be conducted during semester as per the guidelines of MSBTE.
- Self-Learning Assessment of 25 Marks is planned to be undertaken by students to facilitate integration of COs, TLOs and LLOs through Micro project/Activities/ Assignments based on Course Outcome requirements.
- End Semester Theory Examination of 70 marks will be conducted by MSBTE at the end of semester. The schedule of MSBTE Examinations will be announced by MSBTE on the website [www.msbt.com](http://www.msbt.com).

- Rules for Practical Assessment:**

- Progressive assessment of each practical is based on Process related (15 marks) and Product related (10 marks) - Total out of 25 marks as per the assessment scheme prescribed in manual given by MSBTE, Mumbai.
- The Performance Indicators of each practical is assessed according to product and process related skills. Sample format given below:

***Assessment Scheme for Each Practical:***

Sr. No	Performance Indicators	Weightage in %
<b>Process Related(15 Marks)</b>		<b>60%</b>
1	Effective Practical Implementation with Specified Time	25%
2	Effective Handling of Network Component	25%
3	Follow Ethical Practices	10%
<b>Product Related(10 Marks)</b>		<b>40%</b>
4	Correctness of Practical Implementation	15%
5	Timely Submission OF Practical	15%
6	Answer to Sample Question	10%
	<b>Total(25 Marks)</b>	<b>100%</b>

- Final Formative Assessment (FR PR) of 25 marks is calculated based on Progressive Assessment for each experiment.

*Formative Assessment Marks = ((Total Marks Obtained in P.A.) / (25\*Total Number of Experiments))\*25*

4.A comprehensive Final Practical Summative Assessment Semester examination (of 25 Marks) will be Conducted by MSBTE at the end of semester. Examiner for this examination External Examiner will be Appointed by MSBTE. The schedule of MSBTE Practical Examination will be display on Notice board Prior to examination

## **SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)**

### **SUGGESTED STUDENT ACTIVITIES**

1. Prepare report for step-by-step procedure to be followed for artificial respiration to be given to shock affected person.
2. Prepare power point presentation on testing of Induction motor as per IS. Prepare power point presentation related to foundation of transformers.
3. 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**

1. Elaborate various cooling methods of alternator.
2. 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.
3. Elaborate various motor winding temperature measurement methods. Elaborate various transformer cooling methods.

### **Micro project**

1. Collect information on safety signs used for electrically hazardous areas and prepare charts for display in the laboratory or work place.
  - a. 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.
  - b. Prepare a report on diagnosis of transformer oil sample by conducting various tests on it and submit a detailed report.
  - c. 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 :**

1. Above is just a suggestive list of micro projects and assignments; faculty must prepare their own bank of micro projects, assignments, and activities in a similar way.
2. The faculty must allocate judicious mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
3. If a micro project is assigned, it is expected to be completed as a group activity. SLA marks shall be awarded as per the continuous assessment record.
4. For courses with no SLA component the list of suggestive micro projects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.

## • **References:**

### 1. **Books :**

Sr. No	Title	Author	Publisher
01	Electrical Machines	Bhattacharya, S. K.	McGraw Hill Education. New Delhi ISBN : 9789332902855
02	Electrical Technology Vol-II (AC and DC machines )	Theraja B.L.	S.Chand and Co.Ltd., New Delhi ISBN : 9788121924375
03	Electrical Machines Theory and Practice	Bandyopadhyay, M. N.	PHI Learning Pvt. Ltd., New Delhi ISBN : 9788120329973 Vi
04	IS Codes for Transformer	IS 2026 (Part-1 2011, Part2 2010) IS 10028 (Part III- 1981)	--
05	IS Codes for Induction Motor	IS 325-1996, IS 4029-2010, IS 900-1992	---
06	Guide for Testing of Universal and Single phase Induction Motor	IS 7572-1974	

### 2. **LEARNING WEBSITES & PORTALS:**

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

### 3. **Web References:**

1. <https://www.nptel.ac.in>
2. <https://www.wikipedia.com>
3. <https://www.electricaltechnology.org>
4. <https://www.howstuffworks.com>
5. <https://www.electrical4u.com>

### 4. **Tools:** Google Classroom

**Mr.J.M.Patil**

(Name & signature of staff)  
CC: Course File

**Mr.S.B.Pawar**

(Name & signature of HOD)