GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Electrical Engineering / Renewable Energy

Subject Code: DI03000081

Subject Name: Electrical Machines – I

w. e. f. Academic Year:	2024-25
Semester:	3rd
Category of the Course:	PCC

Prerequisite:	**Electrical Engineering Fundamentals, Electric & Magnetic Circuits and Electromagnetism**
Rationale:	Despite technological advancements in electrical technology, DC machines continue to play a significant role in many industrial and commercial applications. Transformers play a critical role in modern power systems, ensuring efficient energy transmission and distribution. This course provides students with core principles and hands-on skills in electrical machines. It builds a strong theoretical and practical foundation for careers in electrical engineering and related fields. By the end of the course, Learners will gain expertise in key components like DC machines and Transformers, preparing them for industry demands.

Course Outcome:

After Completion of the Course, Student will able to:

CO No	Course Outcomes	RBT Level
01	Maintain Various types of DC Generators.	U
02	Evaluate the performance of DC Motors.	A
03	Test the performance of Single-phase Transformers.	A
04	Inspect, Troubleshoot and Maintain Three-phase Transformers.	A

**Revised Bloom's Taxonomy (RBT)*

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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**DC Generators** Contents: (1) D.C. Machine: construction, parts-function and material (2) D.C. Generator: Principle of operation, Faraday's law of electromagnetic induction, Fleming's right-hand rule. (3) E. M. F. equation of D.C. Generator (Derivation). (4) Types of D.C. Generator and it's applications. (5) Characteristics –Magnetic, internal and external. (6) Armature Reaction and Commutation (Briefly). (7) DC Machine: Power Stages, losses, voltage regulation and efficiency.	09	20 %
2.	**D.C. Motors** Contents (1) Principle of operation, Lorentz force, Fleming's Left-hand rule, Back emf and it's significance. (2) Torque: armature torque, shaft torque, Break Horse Power (BHP). (3) Types of D.C. Motors, D. C. Motor characteristics: speed-armature current, torque-armature current, speed-torque. (4) Speed control: D.C. shunt and series motor - flux and armature control, Numerical. (5) Starters, necessity of starters, two-point starters, three-point	12	27 %

	starters (6) Testing of D.C. Machines. (Brake test, Swinburne's test). (7) D.C. Motors applications, advantages and disadvantages.		
3.	**Single phase transformers** Contents: (1) Introduction, Types of transformers: Shell type and Core type, construction, parts-functions and materials used for different parts. (2) Principle of operation, EMF equation, voltage transformation ratio, turns ratio, Numerical. (3) Significance of transformer ratings. (4) No-load and On-load test on transformer and it's phasor diagram, Leakage reactance. (5) Equivalent circuit of transformer with equivalent resistances and reactances. (6) Voltage regulation and Efficiency: Direct load Test, O.C. / S.C. Test, Polarity Test. All day efficiency, Numerical, Applications. (7) Single phase auto transformer: Construction and working.	15	33 %
4.	**Three phase transformers** Contents: (1) Introduction, Working principle of three phase transformer. (2) Construction, bank of three single phase transformers. Single unit of three phase transformer, Cooling Methods. (3) As per IS: 10028 (Part I)-1985 - Selection criteria of distribution transformer and power transformer. (4) As per IS: 2026 (part IV)-1977 - Winding Connections / Vector group of three phase transformers (Star-Star, Delta-Delta, Delta-Star, Star-Delta, Open Delta or V -V connection), Three phase to two phase conversion (Scott Connection), Numerical. (5) Need of parallel operation, conditions for parallel operation.	09	20 %
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25 %	**35 %**	**40 %**	**-**	**-**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1.	Theraja B. L., "Electrical Technology Vol-II (AC and DC machines)", S. Chand and Co. Ltd., New Delhi, ISBN: 9788121924375.
2.	Gupta J. B., "Theory & Performance of Electrical Machine", S-K-Kataria, ISBN-13: 978-9350142776
3.	G. C. Garg & P.S. Bimbhra, "Electrical Machines", Vol-I, II, Khanna Book Publishing House (ISBN:978-9386173-447, 978-93-86173-607), New Delhi.
4.	Kothari D. P. and Nagrath, I. J., "Electrical Machines", McGraw Hill Education. New Delhi, ISBN: 9780070699670.
5.	Mehta V. K. and Mehta, Rohit, "Principles of Electrical Machines", S. Chand and Co. Ltd., New Delhi, ISBN: 9788121930888.
6.	Mittle V. N. and Mittle, Arvind., "Basic Electrical Engineering", McGraw Hill Education, New Delhi, ISBN: 9780070593572.
7.	Bhattacharya S. K., "Electrical Machines", McGraw Hill Education, New Delhi, ISBN: 9789332902855.
8.	Murugesh Kumar K., "DC Machines and Transformers", S. Chand, ISBN: 9788125916055.
9.	Bandyopadhyay M. N., "Electrical Machines Theory and Practice", PHI Learning Pvt. Ltd., New Delhi, ISBN: 9788120329973.

(b) Learning Websites & Web-Portals:

Sr. No.	Web-Link of Websites / Web-Portal	Description
1.	https://youtu.be/D4RFFnzRdkk?si=d5iNRWSZbl01NvT3	Construction & Working Principle of a D.C. Machine. (Lecture – 23 & 24) [DC Machines – Part – 1 & 2]
2.	https://www.youtube.com/watch?v=6dF3LDzb-tE	D.C. Generators. (Lecture – 25 & 26) [DC Generators - Part 1 & 2]
3.	https://youtu.be/1OfLgpFq6Rc?si=bwN9d7ESlV2Utzb6	D.C. Motors. (Lecture – 27, 28 & 29) [DC Motors - Part 1, 2 & 3]
4.	https://youtu.be/qmcriUdYBW0?si=ea5Sa1G9R9m7aRTm	Single Phase Transformers (Mod 01- Lecture 01 to Lecture 08)
5.	https://www.youtube.com/watch?v=s86tXyDQIxg&list=PL59861DBF8EC85491&index=10	Three Phase Transformers (Mod 01- Lecture 10 to Lecture 19)
6.	https://nptel.ac.in/	About construction, working principle and operation of D. C. Machine, D. C. Generators, D. C. Motors, single phase transformers, three phase transformers.
7.	www.electricaltechnology.org	About construction, working principle and operation of D. C. Machine, D. C. Generators, D. C. Motors, single phase transformers, three phase transformers.
8.	www.electrical4u.com	About construction, working principle and operation of D. C. Machine, D. C. Generators, D. C. Motors, single phase transformers, three phase transformers.
9.	https://www.tutorialspoint.com/electrical_machines/index.htm	To enhance understanding of electrical machines with various tutorials
10.	https://innovationspace.ansys.com/product/	To enhance understanding of electrical machines

electrical-machines-and-magnetic-fields/ with various tutorials

Suggested Course Practical List:

The following Practical Outcomes (PrOs) are the sub-components of the Course Outcomes (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 / Title of experiment	CO1	CO2	CO3	CO4
1.	Demonstration of Cut-section of D.C. Machine.	√			
2.	Perform Load test on D.C. Shunt Generator. *	√			
3.	Reversal of direction of rotation of D.C. Shunt Motor.		√		
4.	Perform Speed torque characteristics of D.C. Shunt Motor. *		√		
5.	Perform Speed control of D.C. Shunt motor using Armature control & flux control method. *		√		
6.	Perform Brake test on D.C. Series Motor. *		√		
7.	Perform Brake test on D.C. Shunt Motor.		√		
8.	Demonstration of operating mechanism of two-point starter of a DC series Machine.		√		
9.	Demonstration of operating mechanism of three-point starter of a D.C. Shunt Machine. *		√		
10.	Demonstration of operating mechanism of four-point starter of a D.C. Compound Machine.		√		
11.	Check the functioning of single-phase transformer.			√	
12.	Transformation ratio of single-phase transformer. *			√	
13.	Perform Direct load test of single-phase transformer. *			√	

14.	Perform Open circuit and short circuit test on single-phase transformer to determine equivalent circuit parameters. *			√	
15.	Perform Open circuit and short circuit test on single-phase transformer to determine voltage regulation and efficiency. *			√	
16.	Perform parallel operation of two single-phase transformers to determine the load current sharing. *			√	
17.	Perform polarity test on a single-phase transformer. *			√	
18.	Perform Back-to-Back test on single phase transformer.			√	
19.	Connection of the auto-transformer. *				√
20.	Identify various parts of the three-phase transformer. *				√
21.	Perform Scott-Connection of three-phase transformer.				√

Suggested List of Laboratory/Learning Resources Required:

Sr. No.	Suggested Equipment Name with Specifications
1.	DC series and shunt machines (up to 230 V, 4 kW).
2.	Three-point starter.
3.	Two-point starter.
4.	Single phase transformer of suitable size (500 VA to 1 kVA).
5.	Three phase transformer of suitable size (1 kVA to 3 kVA).
6.	AC Ammeter range (0-2.5-5-10A). Portable Analog MI type as per relevant BIS standard.
7.	AC Voltmeter Range (0-75/150/300V), Portable Analog MI type as per relevant BIS standard.

8.	Wattmeter 0-300/600 V, 5/10 A, for use in A.C. circuits.
9.	L.P.F. Wattmeter, 0-300/600 V, 1A to 2A, for use in A.C. circuits.
10.	Lamp load of 10-20 A.
11.	DC Supply, 230 V, 25 A.
12.	Rheostat (0-500 Ohm. 1.2 A), Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact.
13.	Tachometer (0-10,000 RPM).
14.	DC Ammeter range (0-5-10A), Portable Analog PMMC type as per relevant BIS standard.
15.	DC Voltmeter Range (0-150/300V), Portable Analog PMMC type as per relevant BIS standard.
16.	Rheostat (0-400 Ohm, 1.5A). Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact.
17.	Single phase auto transformer 0-270 V, 15 A.
18.	Rheostat (0-100 Ohm, 5A), Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact.
19.	Rheostat (0-50 Ohm, 10A), Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact.

Suggested Activities / Project List:

1. DC Generator Projects & Activities

Reports / Seminars / Presentations:

- No-Load Characteristics (Open-Circuit Test) – Plot E vs. If (Excitation curve) for shunt/series generators.
- Load Characteristics – Study terminal voltage vs. load current for shunt, series, and compound generators.
- Critical Resistance & Critical Speed – Determine the minimum field resistance and speed for voltage buildup.
- Efficiency Calculation – Perform Swinburne's Test (for small DC machines).

Projects / Activities / Demonstrations:

- Design a Simple DC Generator (Using permanent magnets and armature windings).

- Voltage Regulation Study – Compare shunt vs. compound generator performance under load.
- DIY Hand-Crank Generator – Demonstrate Faraday's law of electromagnetic induction.
- Battery Charging using DC Generator – Design and implement a system to charge a battery using a DC generator.
- DC Generator as a Wind Turbine – Create a wind turbine prototype using a DC generator and measure its output under varying wind conditions.

2. DC Motor Projects & Activities

Reports / Seminars / Presentations:

- Speed Control Methods – Armature resistance control, field flux control, and PWM-based control.
- Torque-Speed Characteristics – Plot graphs for shunt, series, and compound motors.
- Starting Methods – Test 3-point starter operation and observe starting current.
- Braking Techniques – Dynamic, regenerative, and plugging braking demonstrations.

Projects / Activities / Demonstrations:

- Speed Control of DC Motor Using Arduino (PWM) – Build a closed-loop control system.
- DC Motor as a Generator – Reuse a motor to generate power (e.g., wind turbine demo).
- Battery-Powered Mini Electric Vehicle (EV) Model – Use a DC motor for propulsion.
- DC Motor-Powered Conveyor Belt – Create a conveyor belt prototype driven by a DC motor for industrial automation.

3. Single-Phase Transformer Projects & Activities

Reports / Seminars / Presentations:

- Open-Circuit (No-Load) & Short-Circuit Tests – Calculate efficiency and regulation.
- Polarity Test – Identify additive/subtractive polarity using a voltmeter.
- Load Test – Measure voltage regulation at different power factors.
- Parallel Operation – Check conditions for successful parallel connection.

Projects / Activities / Demonstrations:

- Design a Small Transformer (Build a small step-up/step-down transformer and demonstrate its working).
- Isolation Transformer Application – Safety demonstration in labs.
- Transformer-less Power Supply (Capacitive Dropper) – For low-power LED circuits.

- Voltage Stabilizer using Transformer – Design a voltage stabilizer circuit using a single-phase transformer.

4. Three-Phase Transformer Projects & Activities

Reports / Seminars / Presentations:

- Vector Group Testing – Verify Dyn11, Ynd1, etc. using a phase sequence indicator.
- Efficiency & Regulation – Perform load tests on a 3-phase transformer.
- Unbalanced Load Analysis – Study effects on neutral current in Star-connected transformers.

Projects / Activities / Demonstrations:

- Star-Delta Starter for 3-Phase Motors – Using a 3-phase transformer.
- Scott Connection (3-Phase to 2-Phase Conversion) – For special applications.
- Three-Phase Transformer Efficiency Testing – Evaluate the efficiency of a three-phase transformer under different load conditions.

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