GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: D. C. Machines and Transformer
(Course Code: 4330901)

Diploma programmer in which this course is offered	Semester in which offered
Electrical Engineering	Third

1. RATIONALE

The electrical engineering applications in industries use small and large electric motors in some crucial application systems. This course will enable the students to develop skills to select, operate, and maintain various types of D.C. machines and transformers. Practical features of the course will make the students capable of performing various tests on these machines. This course will also make the students familiar with the working and applications of Single-phase transformer and D.C. Machines.

2. COMPETENCY

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

- **Maintain various types of D.C. machines and single-phase transformers safely.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Distinguish types of D.C. Generators.
b) Distinguish types of D.C. Motors.
c) Interpret constructional and operational features of different types of single-phase transformers.
d) Undertake performance test of single-phase transformers.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
4	0	4	6	30*	70	50	50	200

(*): 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 taken 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) 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 (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify various parts of D.C. machine	I	2
2	Perform test on D.C. shunt generator to find out Magnetization characteristic.	I	4*
3	Maintain constant voltage of D.C. generator at different load conditions	I	4*
4	Test the performance of a separately excited D.C. shunt generator	I	4
5	Test the performance of D.C. series generator	I	4
6	Test the performance of D.C. compound machine	I	4
7	Connect three point and four-point starters for D.C. motor.	II	4
8	Control the speed of D.C. series motor.	II	4
9	Control the speed of D.C. shunt motor by armature and field control.	II	4*
10	Perform Hopkinson test on D.C. Machine.	II	6
11	Perform field test on D.C. Series Motor.	II	6
12	Perform Brake test on D.C. Motor.	II	6
13	Perform Swinburne's test of D.C. machine.	II	6
14	Reverse direction of various D.C. Motors.	II	4*
15	Study construction of BLD.C. motor and it's parts.	II	2*
16	Perform parallel operation on two single phase transformers.	IV	4*
17	Perform direct load test on single phase transformer.	IV	4*
18	Perform Sumpner's test on single phase transformer.	IV	6
19	Perform polarity test on single phase transformer.	IV	4*
20	Perform open circuit and short circuit test of single-phase transformer.	IV	6*
21	Troubleshoot of D.C. Machine.	II	4
22	Troubleshoot of single-phase transformer.	III	4
			56 Hrs

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	Prepare experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices.	20
4	Record observations correctly	20
5	Interpret the result and conclude	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
1	D.C. supply, 250 Volt, 25 Amp.	2 to 14
2	D.C. series, shunt, and compound machine (up to 230 V, 5 HP)	2 to 14
3	Single-phase transformer (1-2 KVA, 230/115 V) at least 02 nos.	16 to 20
4	Single-phase auto transformer- 0 to 270 V, 15 Amp.	16 to 20
5	Cut section of D.C. Machine	1
6	Lamp load (10-20 A)	3,4,5,6,17

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

a) Work as a leader/a team member (while doing a micro-project)
b) Follow safety practices while using D.C. and AC supply and electrical equipment.
c) Work as a group member (while performing experiments and taking readings)
d) Practice environmentally friendly methods and processes. (Environment related)

The ADOs are best 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:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. '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 UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit 1 D.C. Generator	1a. Describe material used for various parts of D.C. machine & its function and working of DC generator. 1b. Derive emf equation of D.C. generator. 1c. Distinguish between lap and wave winding. 1d. Differentiate between shunt, series and compound generator. 1e. Compare performance characteristic of different types of D.C. Generators. 1f. Explain armature reaction and commutation 1g. Solve numerical based on emf equation, voltage regulation and efficiency of DC generator.	1.1 Energy conversion principle. 1.2 Construction of D.C. machine. 1.3 Working principle of D.C. generator (single loop generator, action of commutator) 1.4 EMF equation of D.C. generator. 1.5 Armature winding terminology and its types. 1.6 Dummy coils, Equalizer rings. 1.7 Types of D.C. generators. 1.8 Characteristics of various types of D.C. generators. 1.9 Armature reaction and Commutation. 1.10 Power stage and Losses in D.C. machines 1.11 Voltage regulation, Efficiency and condition for maximum efficiency. 1.12 Applications of various types of D.C. generator.
Unit-II D.C. Motors	2a. Explain working of D.C. motor 2b. Derive torque equation of D.C. motor. 2c. Justify the need of D.C. motor starter 2d. Explain working of D.C. motor starter 2e. Classify different types of D.C. motors 2f. Compare performance of different types of D.C. motors 2g. Explain the speed control of D.C. motor 2h. Calculate the losses and	2.1 Working principle of D.C. Motor. 2.2 Significance of the Back EMF. 2.3 Torque in D.C. Motor (armature torque, shaft torque, BHP) and Numerical. 2.4 D.C. motor starter (necessity, two-point, three point and four-point starter) 2.5 Types of D.C. motors and its characteristics and Numerical. 2.6 Speed control of D.C. motor 2.7 Electronic speed control, reversal of rotation.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	efficiency 2i. State the need of Brake test, Swinburne's test and field test. 2j. List the applications of various types of D.C. motors 2k. Explain working of BLD.C. Motor.	2.8 Power stages, Losses, and Efficiency of D.C. Motor and Numerical. 2.9 Testing of D.C. Machines. (Brake test, Swinburne's test, Hopkinson test, field test) 2.10 Applications of D.C. Motors. 2.11 Specifications of D.C. Machines. 2.12 Brushless D.C. Motor (construction and working)
Unit-III Single Phase Transformer	3a. Explain the working of a single-phase transformer with sketches 3b. Derive EMF equation of transformer and transformation ratio 3c. Differentiate between core and shell type transformer with sketches. 3d. State the materials used for the different parts of the transformer 3eExplain the performance of the transformer on no load, resistive, inductive, and capacitive loads with phasor diagrams 3f. Explain various losses in transformer. 3g. Derive expression for efficiency and the condition for maximum efficiency of a single-phase transformer 3h. Describe working of an autotransformer with sketches.	3.1 Construction and working principle of Transformer. 3.2 Material used for core, winding and insulations) 3.3 EMF equation and transformation ratio and Numerical. 3.4 No load and on load phasor diagram. 3.5 Equivalent circuit of transformer (equivalent resistance and reactance) and Numerical. 3.6 Losses of transformer, separation of core loss components and Numerical. 3.7 Efficiency of single-phase transformer and condition for maximum efficiency and Numerical. 3.8 Voltage regulation, application of transformer. 3.9 Auto transformer (construction and working) 3.10 Saving of copper in auto transformer.
Unit-IV Testing of single-phase transformer	4a. State the need for conducting different types of tests on single phase transformers. 4b. Describe the steps for conducting various test of single phase transformer. 4c. Describe the need and conditions for parallel operation of transformers	4.1 Direct load test 4.2 OC and SC test 4.3 Back-to-Back test 4.4 Need of parallel operation 4.5 Conditions of parallel operation in single phase transformer. 4.6 Parallel operation and load sharing of single-phase transformer

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		4.7 Numerical.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	D.C. Generator	16	6	8	6	20
II	D.C. Motor	16	6	8	6	20
III	Single-phase Transformer	16	6	8	6	20
IV	Testing of Single-phase Transformer	08	2	4	4	10
Total		**56**	**20**	**28**	**22**	**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 UOs. 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 undertaken to accelerate the attainment of the various outcomes in this course. Students should perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidence for their (student's) portfolio which may be useful for their placement interviews:

a) Present seminar on various topics from course content
b) Prepare nameplate of D.C. machines and single-phase transformer.

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/subtopics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) Show animation/ video related to course content.
e) Co-relating the importance of content of this course with other courses/ practical applications. (e.g. importance of a content in course or whole course related to A.C. Machines, Transmission and Distribution of Electrical Power, Energy Conservation Switchgear and Protection etc. and in practical industrial &/ domestic applications.
f) Introduce E-waste recycling technology among the students.
g) Guide students on how to address issues on environment and sustainability

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-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 duration of the micro project should be about **12-14** ***(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:

a) Prepare chart showing different material used for various parts of D.C. machines.
b) Collect specification from different manufacturers of D.C. machines and prepare market survey report.
c) Collect specification from different manufacturers of single-phase transformer and prepare market survey report.
d) Prepare simple model of single-phase transformer.
e) Prepare chart of industrial applications of various types of D.C. motor and generator.
f) Prepare chart of application single-phase transformer and auto transformer.
g) Prepare report on power saving in BLD.C. motor.
h) Prepare model of Lap and Wave winding of D.C. Machines.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	A textbook of Electrical Technology Volume-II	B. L. Theraja & A.K. Theraja	S. Chand and Co., New Delhi, 23 edition or Latest edition (ISBN : 9788121924405)
2	Principle of Electrical Machines	V.K.Mehta, Rohit Mehta	S.Chand and Co. Ltd, New Delhi ISBN: 9788121930888
3	Electrical Machines	S.K.Bhattacharya	McGraw Hill Education. New Delhi ISBN:9789332902855
4	Electrical Machinery	Dr. P.S.Bimbhra	Khanna Publication. New Delhi ISBN: 9788174091734
5	Electrical Machine-I	Gupta, J. B.	S. K. Kataria & Sons, New Delhi, ISBN : 9350140551

14. SOFTWARE/LEARNING WEBSITES

WEBSITES

- https://archive.nptel.ac.in/courses/108/105/108105155/
- https://www.electrical4u.com/electrical-engineering-articles/transformer/
- https://electrical4u.in/D.C.-machines/
- https://lectures.gtu.ac.in/
- https://circuitglobe.com/
- https://www.electricaltechnology.org/
- www.vlab.co.in
- www.khanacademy.org

15. PO-COMPETENCY-CO MAPPING:

Semester I	D.C. Machines and Transformer (Course Code:4330901)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design / develo	PO4 Engineering Tools, Experimen-	PO 5 Engineering practices for society, sustainability	PO 6 Project Manage-ment	PO 7 Life-long learning

			pment of solution	tation & Testing	& environment		
Competency	**Maintain various types of D.C. machines and single-phase transformers safely.**						
Course Outcomes CO1 Distinguish types of D.C. Generators.	3	3	1	3	2	-	-
CO2 Distinguish types of D.C. Motors.	3	3	1	3	2	-	-
CO3 Interpret constructional and operational features of different types of single-phase transformers.	3	3	1	-	-	-	-
CO4 Undertake performance test of single-phase transformers.	3	-	-	3	-	-	-

*Legend: '**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

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