



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Engineering**

**Level: UG**

**Subject Code: BE03024021**

**Subject Name: Electrical Machines and Applications- I**

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

Prerequisite:	Fundamental of Electrical Engineering
Rationale:	Electric machine is an essential device to Power Electronics engineering because it powers industry, facilitates technological developments, and converts energy. Students who successfully complete this course will have the fundamentals of electromechanical energy conversion as well as crucial knowledge of principle and operation of machines like motors, generators, and transformers.

**Course Outcome:**

After Completion of the Course, the student will be able to:

Sr. No.	Course Outcomes
1	Elaborate on the principle of electromechanical energy conversion.
2	Describe the constructional details, principle of operation, testing and applications of electrical machine.
3	Analyze the performance of DC machines, transformers and special electrical machine.
4	Evaluate the operating parameters of Electrical machines under various load conditions and select the proper types of electrical machines for the different industrial applications.

**Teaching and Examination Scheme:**

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	TH		Theory		Tutorial / Practical			
						ESE (E)	PA (M)	PA/ (I)	PBL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

**Course Content:**

Unit No.	Content	No. of Hours	% of Weightage
1.	<b>Introduction:</b> Principle of Electromechanical Energy conversion, forces and torque in magnetic field systems – energy balance, energy and force in a singly excited magnetic field system, determination of magnetic force, Co-energy, multi excited magnetic field systems.	6	10



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Unit No.	Content	No. of Hours	% of Weightage
2.	<b>DC Generators:</b> Principle of operation, Action of commutator, constructional features, armature windings, lap and wave windings, simplex and multiplex windings, use of laminated armature, E. M.F. Equation, Methods of Excitation: separately excited and self-excited generators, Types of DC generators, build-up of E.M.F., critical field resistance and critical speed, causes for failure to self-excite and remedial measures, Armature reaction: Cross magnetizing and demagnetizing AT/pole, compensating winding, commutation, reactance voltage, methods of improving commutation, characteristics of generators, separately Excited DC generator, parallel operation of DC generators, use of equalizer bar and cross connection of field windings, load sharing, Applications.	8	20
3.	<b>DC Motors:</b> Principle of operation, Back E.M.F., Torque equation, Types of DC motors, characteristics and application of shunt, series and compound motors, Armature reaction and commutation, Starting of DC motor, Principle of operation of 3 point and 4 point starters, Constant & Variable losses, calculation of efficiency, condition for maximum efficiency. Speed control of DC Motors: Armature voltage and field flux control methods, Ward Leonard method. Methods of Testing: direct, indirect and regenerative testing, brake test, Swinburne's test, Load test, Hopkinson's test, Field's test, Retardation test, separation of stray losses in a DC motor test, Types of Electric Breaking, Applications.	8	20
4.	<b>Single Phase Transformers:</b> Single phase transformer, Constructional details, Core, windings, Insulation, principle of operation, emf equation, magnetizing current and core losses, no load and on load operation, Phasor diagram, equivalent circuit, losses and efficiency, condition for maximum efficiency, voltage regulation, approximate expression for voltage regulation, Losses in Transformers, open circuit and short circuit tests, Sumpner's test, Transformer efficiency, Condition for maximum efficiency, All-day efficiency, Auto transformer, Inrush of switching currents, harmonics in single phase transformers, magnetizing current wave form, Parallel operation of transformers, Applications.	8	20



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Unit No.	Content	No. of Hours	% of Weightage
5.	<b>Three phase Transformer:</b> Constructional features of three phase transformers – three phase connection of transformers, Delta-Delta, Star-Star, Delta-Star, Star-Delta, Zigzag, Scott connection, open delta connection, three phase to six phase connection, three phase to twelve-phase connection, oscillating neutral, tertiary winding, three winding transformer, equal and unequal turns ratio, parallel operation, load sharing. Distribution transformers, all day efficiency, Autotransformers, saving of copper, applications, tap- changing transformers, Instrument Transformer, Current Transformer, Difference between Current Transformer and Power Transformer cooling of transformers, Applications.	8	20
6.	<b>Special Electrical Machine:</b> <b>Stepper Motor:</b> Types of Stepper Motor – torque equation – Characteristics of stepper motor – Comparison of stepper motor – Application. <b>PMDC Motor:</b> Types of PMDC and PMLBDC – torque equation and equivalent circuit – Performance Characteristics of PMDC – Comparison of PMDC and PMLBDC – Application.	5	10
<b>Total</b>		<b>45</b>	<b>100</b>

## Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (%)					
R Level	U Level	A Level	N Level	E Level	C Level
40	20	20	15	05	0

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

## References/Suggested Learning Resources:

### (a) Books:

Sr. No.	Title
1	A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2	P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
3	E. G. Janardanan "Special Electrical Machine", PHI, 2019
4	I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.



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5	S K Bhattacharya, "Electrical Machines", Tata Mc Graw Hill, New Delhi
6	S K Sahdev, "Electrical Machines", Unique International Publications, Jalandhar

(b) **Open source software and website:**

1. <https://nptel.ac.in/>
2. <https://ems-iitr.vlabs.ac.in/List%20of%20experiments.html>

**Suggested Course Practical List:**

Sr. No.	List of Experiment
1	To obtain Magnetizing Characteristics, Internal & External Characteristic of Self Excited DC Shunt Generator. Also, obtain the critical field resistance of the machine from magnetizing Characteristics.
2	To conduct direct load test on a D.C. compound generator with a) Shunt field alone b) Cumulative and differential compounding for short and long shunt connections.
3	To obtain Speed-Torque characteristics of DC Series Motor
4	To obtain Speed-Torque characteristics of DC Shunt Motor.
5	To operate two single phase transformers of different KVA ratings in parallel and plot the variation of currents shared by each transformer versus load current.
6	To perform Open Circuit and Short Circuit Test on a transformer and find its efficiency and regulation. Speed control of DC Shunt Motor using a) Armature control and b) field control methods
7	To conduct Sumpner's test on two identical single-phase transformers and determine their efficiency at various loads.
8	To make Scott connection of two single-phase transformer and to verify the current relation by drawing phasor diagrams for (a) Balanced and (b) Unbalanced resistive loads.
9	To conduct open circuit and short circuit test on a three phase three winding transformer and determine the equivalent circuit parameters.
10	To Study stepper motor control using ATMEGA-16 Microcontroller.
11	To study characteristics of PMDC Motor.

**List of Laboratory/Learning Resources Required:**

Learning website:

1. <https://ocw.mit.edu/courses/6-685-electric-machines-fall-2013/pages/course-notes/>
2. <https://nptel.ac.in/courses/108105017/>
3. <http://vlabs.iitkgp.ac.in/rtes/exp10/index.html>  
(Link for Stepper Motor Control Using ATMEGA-16 Microcontroller)
4. [https://sites.google.com/a/vgecg.ac.in/powerelectronics/academic/semester\\_iii/electrical-machine-and-application-3132407](https://sites.google.com/a/vgecg.ac.in/powerelectronics/academic/semester_iii/electrical-machine-and-application-3132407)



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## Any Other:

Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work. The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.

### • List of suggested activities for Problem Based Learning:

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
4.	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding based assignment of 2h each. Total = 10h	Based on the coding solution submitted.
5.	Self learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
7	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
8	Discussion on research paper based on relevant subject	5 research paper = 20 h	Summarize research paper and evaluation critical parameters



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9.	Poster/chart/power point preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration = 15 h for industrial exposure  Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration = 10 h	Depending on the complexity of the Application/Software
15	Blog or Technical Article Writing	10h (Research – 6h, Writing – 4h)	Based on originality, technical content, references cited, and clarity of communication.
16	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
17	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
18	Tech Blog/YouTube Channel Curation	10h (Content curation + Analysis)	Summary report on curated content and learning outcomes.
19	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.



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20	Maintenance or Troubleshooting Logbook	10h (For example: lab instruments, computer hardware)	Based on documented cases, approach, and resolution.
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**Note:**

- All the suggested activity should be related to the subject.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
- Rubrics for the evaluation can be prepared by the faculty.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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