GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140913
Semester – IV
Subject Name: Electrical Machines – I

Type of course: Professional Core Course

Prerequisite: NA

Rationale: Electrical power sector is the backbone of industries, agriculture, irrigation, urban development and almost all the segments of society. Electricity is the primary requirement for the growth of ICT. In view of this, the static and rotating electrical equipments play a vital role for the society. This subject deals with basic principles of electromechanical energy conversion, DC machines and Transformers.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Magnetic fields and magnetic circuits:** Review of magnetic circuits - MMF, flux, reluctance, inductance; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air. Review of Ampere's law and Biot Savart law.	**06**
2	**Principles of Electromechanical Energy Conversion:** B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element.	**06**
3	**DC Machines:** Review of construction and working of a DC machine, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation – Elementary armature coil and commutator, lap and wave windings, construction of commutator, Commutation, Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction. Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, voltage build-up in a shunt generator, critical field resistance and critical speed.	**15**

	V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control methods. Losses and Efficiency in DC machines. Swinburn's test, Hopkinson's test, Field test, Retardation test, Separation of losses of a DC shunt machine.	
4	**Transformers:** Review of construction and working principle of single-phase and three-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency. Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phase transformer - construction, types of connection and their comparative features, Vector groups, Parallel operation of single-phase and three-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.	**15**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**30**	**20**	**10**	**10**	**00**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy) Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. I J Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
3. J B Gupta, "Theory and Performance of Electrical Machines", Katson Publication, 2009.
4. B L Theraja, "Electrical Technology – Part II", S Chand Publications, 2011
5. A E Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.
6. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
7. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Describe the principles of magnetic circuit and electromechanical energy conversion	30

CO-2	Comprehend the construction, working, testing, speed control and applications of DC machines and transformers	50
CO-3	Analyze the performance of DC machines and transformers	10
CO-4	Evaluate the operating parameters of machines under various load conditions	10

List of Experiments:

- 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.
- 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.
- To obtain Speed-Torque characteristics of DC Series Motor and DC Shunt Motor.
- To determine the efficiency of two similar shunt machines by regenerative method. (Hopkinson's Test.)
- To perform field test on identical D.C. series machines.
- To determine the various losses in a D.C. machine and separation of its core losses.
- To perform direct load test on a D.C. shunt motor and plot variation of (a) Input current (b) Speed(c) Torque (d) Efficiency versus output power.
- To separate hysteresis and eddy current losses of a single phase transformer at rated voltage, frequency by conducting no load tests at different frequencies keeping V/f constant.
- 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.
- To conduct Sumpner test on two identical single phase transformers and determine their efficiency at various loads.
- To make Scott connection of two single phase transformer and to verify the three phase to two phase conversion.
- To conduct open circuit and short circuit test on a three phase transformer and determine the equivalent circuit parameters.
- To perform Swinburn's test on DC shunt motor to find out its efficiency
- Speed control of DC Shunt Motor using a) Armature control and b) field control methods.

Major Equipments:

The necessary no. of machines, panels, meters, accessories and instruments etc… to be provided to conduct the above experiments in a group of maximum 4 students. Charts and cut section models of various machines should be provided for better understanding.

List of Open Source Software/learning website:

- http://www.scilab.org/
- http://www.gnu.org/software/octave/
- http://www.vlab.co.in
- http://www.femm.info