GUJARAT TECHNOLOGICAL UNIVERSITY

SUBJECT NAME: Design of AC Machines
SUBJECT CODE: 2170909
B.E. 7TH SEMESTER

Type of course: Engineering Science (Electrical)

Prerequisite: Elements of Electrical Engineering, Elements of Electrical Design

Rationale: The design of most of the electrical equipments (machines) is an iterative process. The final objective is to design the most efficient equipment, with minimum size, weight and cost. There are number of constraints in the actual design process. Research in the field of materials science directly affects the design of machines. This subject focuses on conventional design procedure for AC machines as well as the application of computers for machine design.

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)	
					PA	ALA	ESE	OEP		
3	00	02	05	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment.

Learning Objectives:

1. To understand the design of Induction machines and synchronous machines.
2. To improve analytical skills with the help of numerical problems.
3. To learn about preparation of detailed drawings for equipments based on design.
4. To learn the basics of computer aided design.

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	**DESIGN OF THREE PHASE INDUCTION MOTOR:** MAIN DIMENSIONS: Output equation, choice of specific loadings, separation of D and L. STATOR DESIGN: Stator winding design, Calculation of no. of turns per phase, Conductor's area, Shape of the stator slots, Area of stator slots, Stator teeth design, Depth of the stator core, Length of air gap, Numerical problems related to above topics. ROTOR DESIGN: A. Squirrel cage rotor – Selection of no. of rotor slots, Effect of harmonics and choice of rotor slots to minimize harmonics, vibration, noise and voltage ripples, Rules for selecting no. of rotor slots, Methods for reducing harmonic torque, Design of rotor bars and rotor slots. Design of end rings and rotor core. B. Wound rotor - Calculation of number of rotor slots, Number of turns, Cross sectional area of rotor conductors, Types of rotor windings, Check for rotor tooth density, Design of rotor slot and rotor core.	**15**	**35**

	PERFORMANCE PARAMETERS EVALUATION: No load current calculation, Stator and rotor resistance and reactance calculation, Circle diagram, Dispersion coefficient – effect on maximum output power factor Design aspects for large size machine, High voltage machine, High speed machine. Design of submersible motors. Numerical problems based on above topics. Computer programs and flow charts based on above topics.		
2.	**DESIGN OF SINGLE PHASE INDUCTION MOTOR:** Design of main dimensions, Design of stator, Design of rotor, Design of auxiliary winding. PERFORMANCE PARAMETERS EVALUATION: Rotor resistance, Stator resistance, Iron loss, Friction and Windage loss, Starting torque, Circle diagram, Calculation of capacitance for maximum torque.	**6**	**15**
3.	**DESIGN OF SYNCHRONOUS MACHINE:** Output equation and design of main dimensions, Short Circuit Ratio (SCR) and its significance, Length of air gap and shape of pole face. ARMATURE DESIGN: Armature winding (Single layer and double layer), Number of armature slots, Slot dimensions, Length of mean turn, Calculation of armature resistance and reactance. DESIGN OF FIELD SYSTEM: Design of magnetic circuit, Open circuit characteristic, Determination of full load field MMF, Design of field winding, Determination of direct and quadrature axis synchronous reactance, Short circuit characteristics. DESIGN OF TURBO ALTERNATORS: Main dimensions, Length of air gap, Stator & Rotor design. Design considerations for low speed alternators and vertically operated alternator. Computer programs and flow charts based on above topics.	**15**	**35**
4.	**APPLICATION OF FINITE ELEMENT METHOD IN DESIGN:** Introduction to FEM, Application of FEM technique for design problems. Use of open source FEM software for 2D design. Computation of performance parameters of machine using FEM software.	**6**	**15**

NOTE : Minimum 30 to 40% weightage should be given to numerical problems in the theory exams.

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**Total**
15	**15**	**10**	**10**	**20**	**70**

Legends: R : Remembrance ; U = Understanding; A = Application; N = Analyze; E = Evaluate (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. A Course in electrical machine design – A. K. Sawhney, Dhanpat Rai and Sons
2. Electrical machine design – R. K. Agrawal, S.K. Kataria & Sons
3. Design of Electrical machines – V. N. Mittle, Standard Publishers Distributors
4. Design and Testing of Electrical Machines – M V Deshpande, PHI

5. Electrical Machine Analysis using Finite Elements – Nicola Bianchi, Taylor and Francis

Course Outcome:

After learning the course the students should be able to:

- Design the Induction and Synchronous machines of given specifications.
- Prepare the detailed sketches of the designed machine.
- Use computer for electrical machine design.

List of Experiments and Open Ended Problems: (This is a suggestive list only)

During the laboratory hours, the design problems based on the syllabus should be assigned to the students. After carrying out the detailed design, drawing sketches should be prepared by the students.

(1) Design of three phase squirrel cage induction motor
(2) Design of three phase slip ring induction motor
(3) Design of single phase induction motor
(4) Design of submersible motor
(5) Design of turbo alternator
(6) Design of salient pole low speed alternator
(7) Practice problems on open source software (FEMM)
(8) Performance parameters evaluation using FEM software

Major Equipment:

Lab set ups of following machines

(1) Cut section models of (a) Induction machine (b) Synchronous machine
(2) Charts to explain various parts of machines

List of Open Source Software/learning website:

- http://www.electrical-engineering-portal.com/
- http://nptel.iitm.ac.in/courses.php
- http://www.femm.info
- www.vlab.co.in

ACTIVE LEARNING ASSIGNMENTS: 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.