Electrical Machines

Code	Credit Hours
EE- 260	3-1

Course Description

This course familiarizes the students with the principles of electrical machines. It includes lectures (audio/video aids), written assignments/quizzes, tutorials, case studies relevant to engineering disciplines, semester project, guest speaker, industrial/ field visits, group discussion, and report writing.

Text Book:

1. Electric Machinery Fundamental, Latest Edition, Stephen J. Chapman, McGraw-Hill International

Reference Book:

1. Fitzgerald, Kingsley and Umans, "Electric Machinery", McGraw-Hill. (Latest Edition)
2. Hindmarsh, "Electrical Machines", McGraw-Hill. (Latest Edition)
3. Theodore Wildi "Electrical Machines, Drives, and Power Systems

Prerequisites

NIL

ASSESSMENT SYSTEM FOR THEORY

Quizzes	10%
Assignments	10%
Mid Terms	30%
ESE	50%

Teaching Plan

Week No	Topics	Learning Outcomes
2	Introduction to Electrical Machinery Principles	Introduction to magnetic field and circuits Faraday's and Lenz's law Magnetization curves Characteristics of hard and soft magnetic materials Losses
3-5	DC generators and motors	Parameters and Equivalent circuits of DC Machines and the relationships between speed Power and torque
6	**MID TERM IN WEEK 9**	
7-8	AC motors and generators	Parameters and equivalent circuits of AC Machines Rotating magnetic field The induced voltage and torque Phasor diagrams and the relationships between speed power, torque
9	**MID TERM EXAM**	
10-16	Transformers Equivalent circuit and phasor diagrams	Equivalent circuit of practical transformers Approximate equivalent circuit, and equivalent circuit referred to primary and secondary sides Phasor diagram of ideal and practical transformer without load Phasor diagram of secondary side of practical transformer with unity Lagging and leading power factor Complete phasor diagram of practical transformer

17-18	Transformer Tests, Transformer Taps and Voltage regulation, DC Generator, DC Motors, DC series motor	Open circuit Test and calculations of magnetizing branch parameters Short circuit test and calculation of impedance Efficiency calculations Calculation of maximum efficiency Output for maximum efficiency Transformer taps Voltage regulation Reasons of voltage drop Voltage regulation under different load conditions Transformer phasor diagrams Types of DC generators Equivalent circuit and characteristic equations Separately excited generator Shunt generator Voltage build-up phenomenon Series generator Compounded generator and its type; under compounded Over compounded and flat compounded generator Voltage control in all generators and terminal characteristics of all the generators Working principle, construction, and operation Important parts of DC motor Different types of DC motors Equivalent circuits and terminal equations Magnetic characteristics of DC machines Terminal characteristics of separately excited and shunt type DC motor. Construction and working of stepper motor Brushless DC motor and switched reluctance motor Expression for torque, applications, terminal characteristics Six methods for speed control

	Armature Reaction, Commutation, Tests and Losses, Design of Armature Winding, Introduction to AC Machines, Introduction to AC Machines	Concept of magnetic and magnetic neutral axis Placement of carbon brushes Armature reaction and its causes Components of armature reaction Effects of armature reaction Remedies for armature reaction Compensating winding, flux enhancement and brush shifting Commutation process Commutation time Ideal commutation Poor commutation Effects of poor commutation Practical difficulties Ldi/dt effect, interpoles Function of interpoles. Different types of tests Losses and their formulation Power flow diagram of motor and generator Calculation of maximum efficiency Calculation of losses at different loads Pole pitch, coil pitch, front pitch, commutator pitch Multiplex winding, slap winding, wave winding, design examples of lap winding Developed diagram, sequence diagram, parallel path diagram, characteristics of lap winding, derivation of induced EMF. Introduction to single phase, two phase and three phase systems Waveforms and equations, phasor and polar representation, balanced and unbalanced poly phase systems Types of AC motors: Main parts, Stator windings, concentrated winding, distributed winding, full pitched winding, fractional pitched winding, pole formation in AC machines, revolving magnetic field in three phase machines Nature of magnetic field, properties of DC Single phase, two phase and three phase fields, phase sequence Reversal of magnetic field in three phase machines Speed of revolving magnetic field, conditions to produce RMF Phase splitting in single phase machines Analytical proof of revolving magnetic field and basic mathematical expression for machines

	Induction motor and Hysteresis motor, Power and Torque Calculations, Speed Control of Induction motor, Tests on Induction motor, Synchronous Generator	Construction, working and principle of Induction motor Development of induced torque in induction motor Types of induction motor, squirrel cage and slip ring induction motor and their merits Demerits and comparison, concept of rotor slip and its expression Concept of rotor frequency and its relationship with slip Equivalent circuit of induction motor Rotor circuit and slip effects Final equivalent circuit Working and construction of hysteresis motor Power flow diagram of induction motor Calculation of different losses in an induction motor Modification of equivalent circuit including Rconv The venin voltage and impedance calculation Calculation of current in rotor circuit Expression of induced torque Torque speed characteristics, variation of torque speed characteristics with rotor resistance and stator frequency Pole changing method Line frequency method Voltage control method V/f control for controlling the speed Rotor resistance control method and torque speed characteristics for each method Load torque curves No load test Blocked rotor test Resistance test and calculation of R1, R2, Xm, X1 and X2 using the data of tests Basic principle and working Different types of prime movers Salient pole and cylindrical rotors and their comparison Brushless exciters Pilot exciters Application of synchronous generators Synchronous speed expression DC excitation and use of permanent magnets

	Control of a synchronous generator, Salient pole synchronous generator	Throttle, control of active power Power frequency characteristics Modes of operation of synchronous generator Working alone, working in parallel with same SG, and connected to infinite bus bar, house diagram and sharing of power Effect of excitation keeping throttle constant Effect of throttle keeping excitation constant Effect of throttle keeping excitation and power factor constant q and d axis and reactance and their calculations Phasor diagram of salient pole machines Derivation of power and torque expressions Comparison of cylindrical and salient pole synchronous generator Calculation of equivalent circuit parameters and synchronization of alternator with infinite bus bar
19		**End Semester Exams**