

ELECTRICAL MACHINES AND INSTRUMENTS

(Core Subject)

Course Code:	10B11EC311	Semester:	3 rd Semester, B. Tech (ECE, CE)
Credits:	4	Contact Hours:	L-3, T-1,P-0

Course Objectives

The objectives are to study

1. To prepare students to perform the analysis of any electromechanical system.
2. To empower students to understand the working of electrical equipment used in everyday life.
3. To prepare the students for advanced courses in robotics.

Course Outcomes

1. The ability to formulate and then analyze the working of any electrical machine using mathematical model under loaded and unloaded conditions.
2. The skill to analyze the response of any electrical machine.
3. The ability to troubleshoot the operation of an electrical machine.
4. The ability to select a suitable measuring instrument for a given application.
5. The ability to estimate and correct deviations in measurements due to the influence of the instrument and due to the accuracy of the instrument.

Course Contents

Unit	Topics	References (chapter number, page no. etc)	Lectures
1.	Magnetic Circuits Magnetomotive Force (MMF); Magnetic Field Strength; Permeability, Reluctance, Permeance; Analogy between Electric and Magnetic Circuits.	Text Book # 1 Chapter No.6 Page No.164	2
2.	Transformers • Principle of Operation, EMF Equation; Ideal Transformer, Conditions for Ideal Transformer, Transformation Ratio, Volt-Amperes, Impedance Transformation. • Practical Transformer at No Load, Effect of Magnetization, Effect of Core Losses: (i) Hysteresis Loss, (ii) Eddy-Current Loss; Construction of Transformer, Core of Transformer: (i) Core Type Transformer; (ii) Shell Type Transformer. • Ideal Transformer on Load; Practical Transformer on Load : Effect of Winding Resistance, Effect of Flux Leakage; Equivalent Circuit of a Transformer, Phasor Diagram, Simplified Equivalent Circuit, Approximate Equivalent Circuit	Text Book # 1 Chapter No.13 Page No. 372	8

	<ul style="list-style-type: none"> • Voltage Regulation of a Transformer, Approximate Voltage Drop, Exact Voltage Drop; Condition for Zero Regulation, Condition for Maximum Regulation. • Efficiency of a Transformer; Condition for Maximum Efficiency; All-day Efficiency. 		
3	<p>Electrical Instruments</p> <ul style="list-style-type: none"> • Essentials of an Instrument : (1) Deflecting Torque; (2) Controlling Torque : (i) <i>Spring Control</i>, (ii) <i>Gravity Control</i>); (3) Damping Torque, Methods of Obtaining Damping Torques (1) <i>Air Friction Damping</i>, (2) <i>Fluid Friction Damping</i>, (3) <i>Eddy-Current Damping</i>. • Permanent Magnet Moving Coil (PMMC) Instruments; Ammeters; (<i>Multi-Range Ammeter</i>); Universal Shunt for Extending Current Ranges; Voltmeters; (<i>Multi-Range Voltmeter, AC Voltage Measurement</i>). • The Series-Type Ohmmeter; Meter Sensitivity(Ohms-Per-Volt rating); Loading Effect; Multimeter; Dynamometer Wattmeter; Single- Phase Induction Type Energy Meter. 	Text Book # 1 Chapter No.18 Page No. 589	4
4	<p>Synchronous Machines</p> <ul style="list-style-type: none"> • Electro-Mechanical Energy-Conversion Machines : Power Considerations for a Generator; Power Considerations for a Motor; How a Generator Differs from a Motor; How Mechanical Force is Developed in a Machine; Type of Rotary Machines. • General Characteristics of the Synchronous Machine; Synchronous Speed; Rotating Magnetic Flux due to Three-Phase Currents; EMF Equation • Synchronous Motors; Phasor Diagrams for Generator and Motor; Constant Speed Operation; Operation of a Synchronous Motor : Effect of Change in Mechanical Load, Effect of Change in Excitation, Synchronous Condenser. 	Text Book # 1 Chapter No.14 Page No. 425	8
5	<p>Induction Motor</p> <ul style="list-style-type: none"> • Principle of Working; Slip of Induction Motor; (<i>Frequency of Rotor Currents, Speed of Rotation of Rotor-Field</i>); Construction of Induction Motor (<i>Squirrel Cage Rotor, Wire- or Phase-Wound Rotor</i>). Rotor EMF, Current and Power Factor (<i>Rotor Impedance, Rotor current, Power</i> 	Text Book # 1 Chapter No.15 Page No. 476	6

	<p><i>Factor</i>).</p> <ul style="list-style-type: none"> • Torque-Slip Characteristics: Starting Torque; Torque-Slip Characteristic Curve; Three Modes of Operation : (1) Motor Action, (2) Brake Action, (3) Generator Action; Condition for Maximum Torque; Maximum Torque; Effect of Rotor Resistance on the Starting Torque. 		
6	<p>Electronic Instruments</p> <ul style="list-style-type: none"> • Cathode Ray Oscilloscope: Construction, Working and Applications. • Digital meters; Function Generators. 	Text Book # 2 Chapter No.14 Page No. 446	2
7	<p>DC Machines</p> <ul style="list-style-type: none"> • Construction of a DC Machine; Armature Winding : (1) <i>Lap Winding</i>, (2) <i>Wave Winding</i>; EMF Equation for a DC Generator • Types of DC Machines; A DC Machine as Generator or Motor; Types of DC Generators (<i>permanent magnet generators, separately excited generators, self-excited generators</i>); Losses in a DC Machine : (1) Copper Losses (<i>Armature Copper Loss, Field Copper Loss, Brush Contact Loss</i>); (2) Magnetic (or Iron) Losses (<i>Hysteresis Loss, Eddy- Current Loss</i>); (3) Mechanical Losses (<i>Air Friction (or Windage) Loss, Bearing Friction Loss</i>); Efficiency of a DC Generator, Condition for Maximum Efficiency. • Characteristics of DC Generators; Open-Circuit Characteristic (OCC) (<i>The Field Resistance Line, Building Up of Voltage, Critical Field Resistance, Critical Speed</i>). • DC Motors; Equivalent Circuit of a DC Motor; Speed Regulation of a DC Motor; Torque Developed by a DC Motor; Torque and Speed Characteristics of a DC Motor. 	Text Book # 1 Chapter No.16 Page No. 513	8
8	<p>Fractional Horse Power Motors</p> <ul style="list-style-type: none"> • Introduction; Single-Phase Motors; Problem With Single-Phase Motor; What Can be Done to Run the Single-Phase Induction Motor; Double-Field Revolving Theory; The Remedy (<i>Two-Phase Motor</i>); Types of Single-Phase Motors. • Stepper Motors: Types of Stepper Motors; Variable Reactance (VR) Stepper Motors : (1) One-Phase on Mode, Full-Step Operation; Step Angle; Resolution; Speed; (2) Two-Phase on Mode, Full- Step Operation; (3) Alternate One-Phase on Mode & Two-Phase on Mode, Half-Step Operation; (4) Microstepping. 	Text Book # 1 Chapter No.17 Page No. 561	4
Total Number of Lectures			42

Evaluation Scheme

1. Mid Sem Exam : 30 Marks
2. End Marks Exam : 45 Marks
3. Teacher's Assessment : 25 Marks
4. **Internal Assessment** : 25 marks
 - 10 Marks : Class performance, Tutorials & Assignments
 - 10 Marks : Quizzes
 - 5 marks : Attendance

Text Books

1. D C Kulshreshtha: Basic Electrical Engineering: McGraw Hill Education, 2011.

Reference Books

1. V.N. Mittle and Arvind Mittal: Basic Electrical Engineering, Tata McGraw Hill Publishing Co.
2. Helfrick and Cooper: Modern Electronic Instrumentation and Measurement Techniques, PHI