ELECTRICAL MACHINES – I

Course Code: 22EE1103

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Prerequisite: Ordinary Differential Equation and Vector Calculus

Course Outcomes: At the end of the Course the student shall be able to

- **CO1** Apply the concepts of magnetic circuits to compute induced emf and force in electromagnetic systems
- **CO2** Illustrate the working principle of different types of DC generators
- **CO3** Illustrate the working principle of different types of DC motors including testing
- **CO4** Determine the equivalent circuit of a transformer and assess its performance
- **CO5** Explain the operation of three phase transformers and Autotransformers

UNIT-I 10 Lectures

MAGNETIC CIRCUITS:

Introduction, Magnetic Circuits, B-H relationship, Magnetic materials and their properties, magnetically induced emf and force, AC operation of magnetic circuits, hysteresis and eddy current losses.

PRINCIPLES OF ELECTROMECHANICAL ENERGY CONVERSION:

Energy in magnetic system, field energy and mechanical force, Determination of mechanical force, mechanical energy, Flow of energy in electromechanical device.

Learning outcomes: Student should be able to

1. explain magnetic materials and their properties(L2)
2. determine the magnitude of emf induced and force in electromagnetic system (L3)
3. describe energy in magnetic system(L2)

UNIT-II 10 Lectures

DC GENERATORS

Constructional details of DC machine, armature windings and its types, Emf equation, wave shape of induced Emf, armature reaction, commutation, methods of excitation-Separate Excitation-Shunt Excitation-Series Excitation -Compound Excitation, OCC and load characteristics of different types of DC generators.

Learning outcomes: the student should be able to

1. explain the constructional details of DC machines (L2)
2. determine OCC and load characteristics of different types of DC generators (L3)
3. describe armature reaction and process of commutation in a DC machine (L2)

UNIT-III 10 Lectures

DC MOTORS

Force on conductor carrying current, Torque and power developed by armature, characteristics of DC motors-Separately excited motor-Shunt Motor-Series Motor-Compound Motor, Starting of DC motors, speed control of DC motors-Shunt Motor-Series Motor, Losses and efficiency in DC machine

TESTING OF DC MACHINES: Brake test, Swinburne's test, Hopkinson's test, Retardation test, Separation of iron and frictional losses

Learning outcomes: The student should be able to

1. determine the torque from parameters of DC motor (L3)
2. analyze the characteristics of DC motor and determine the performance (L4)
3. determine various losses and efficiency in DC machines (L3)

UNIT-IV 10 Lectures
TRANSFORMERS

Principle, construction and operation of single-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, per unit system, transformer cooling-natural cooling and forced cooling.

Learning outcomes: The student should be able to

1. explain construction and principle of operation of a transformer (L2)
2. determine the parameters of equivalent circuit to predetermine efficiency and voltage regulation of transformer(L3)
3. test the transformer for determining performance (L4)

UNIT-V 10 Lectures
THREE-PHASE TRANSFORMERS

Construction, types of connection and their comparative features, Phase conversion –Three/Two phase conversion (Scott connection).

Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current

Parallel operation of single-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformers

Learning outcomes: The student should be able to

1. explain the conditions required parallel operation of transformers (L2)
2. distinguish between different types of connections of 3-phase transformer with respect to phasor diagram and connections (L2)
3. describe Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current(L2)

TEXT BOOK:

1. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

REFERENCES:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.
3. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.

4. P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.

WEB REFERENCES:

1. Lecture Series on Electrical Machines - I by **Prof. Tapas Kumar Bhattacharya** , Department of Electrical Engineering, **Indian Institute of Technology, Kharagpur**
https://nptel.ac.in/courses/108/105/108105155/
2. Lecture Series on Electrical Machines by **Professor G. Bhuvaneswari** , Department of Electrical Engineering, **Indian Institute of Technology, Delhi**
https://nptel.ac.in/courses/108/102/108102146/
3. Lecture Series on Electrical Machines-1 by **Prof. D. Kastha** , Department of Electrical engineering, **Indian Institute of Technology, Kharagpur**
https://nptel.ac.in/courses/108/105/108105017/