**DEPARTMENT OF ELECTRICAL ENGINEERING**

**Course Descriptive File**

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| 1 | Course Title | Electrical Machines |
| 2 | Course Code | EE 321 |
| 3 | Credit Hours | 4(3,1) |
| 4 | Pre-requisites | Electrical Network Analysis |
|  5 |  Co-requisites | Advanced Electrical Machines, Electrical Machine Design And Maintenance |
| 6 | Semester | IV |
| 7 | Resource Person | Ms. Aisha Jilani |
| 8 | Contact Hours (Theory) | 3 |
| 9 | Contact Hours (Lab) | 3 |
| 10 | Office Hours  | 8 am to 3 pm |
| 11 | Email | aishajilani90@yahoo.com |
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| 12 | Course Outline as per Scheme of Studies ( SoS) |
| Introduction to Electrical Machinery Principles (1 CH): Magnetic field and circuits, Faraday’s and Lenz’s law, magnetization curves characteristics of hard and soft magnetic materials, losses. Single Phase Transformers (12 CH): Introduction and fundamental concepts, working principle, types, construction, ideal transformer, operation and equivalent circuit, voltage regulation, losses, open and short circuit test, efficiency, instrument and auto transformers, name plate ratings and applications. DC Generator and Motor (13 CH): Introduction and fundamental concepts, working principle, types, construction, operation, EMF equations, torque equations, characteristics, commutation, armature reaction, speed and voltage regulation, losses, open and short circuit test, no load and blocked rotor test, name plate ratings and applications. Induction and Synchronous Machines (22 CH): Introduction and fundamental concepts, working principle, rotating magnetic field, magneto motive force and flux distribution, types, construction, operation, EMF equations, torque equations, speed and voltage regulation, losses, open and short circuit test, no load and blocked rotor test, name plate ratings and applications. Special Purpose Motors: Introduction to Single phase Induction Motors, Switched Reluctance motors, Hysteresis motors, Stepper, brushless DC motors. |
| 13 | Course Objectives as per SoS |
| 1. Develop intuitive concepts regarding fundamental electromagnetic laws governing working of electrical machines including AC transformers, generators and motors.
2. Develop deep insight relating to construction, detailed working and modern day applications of mentioned electrical machines.
3. Understand the basic principles that govern electro-mechanical motion and transformation of electrical energy. By applying this knowledge, students learn techniques that enable them to understand operation of AC electrical machines and analyze their performance.
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| 14 | Books  |
| Recommended Books:1. Stephen J. Chapman, "Electric Machinery Fundamentals", McGraw-Hill. (Latest Edition)
2. Fitzgerald, Kingsley and Umans, "Electric Machinery", McGraw-Hill. (Latest Edition)
3. Hindmarsh, "Electrical Machines", McGraw-Hill. (Latest Edition)
4. Theodore Wildi “Electrical Machines, Drives, and Power Systems”
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| 15 | Course Learning Outcomes (CLOs) |
| After successful completion, students will be able to:Theory CLOs:CLO 1: Apply the concepts of magnetic fields to analyze magnetic circuits, magnetic flux, permeance, reluctance etc.CLO 2: Study of basic concepts involve in principle of operation of a transformer, and compute various parameters of transformer. Compute the various parameters of DC generators and motors, their equivalent circuits, the relationships between speed, power, torque, and applications. CLO3: Compute the various parameters of AC motors and generators, their equivalent circuits, rotating magnetic field, the induced voltage and torque, phasor diagrams and the relationships between speed, power, torque and, applications. Lab CLOs:CLO 4: Perform experiments in a laboratory enabling the students to gain insight into the functioning of transformer, ac and dc machines. |
| 16 | Marks Breakup  |
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| Quizzes | 15% |
| Homework/assignments  | 15% |
| Midterm exam | 30% |
| Terminal exam (3 hours) | 40% |
| Total (theory) | 100% |

Theory

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| Lab Assessments | 30% |
| Lab Sessional Exams(50% Lab performance + 50% Lab Assessments) | 30% |
| Lab Terminal Exam  (xx% Lab performance + xx% Lab Assessments) | 40% |
| Total (lab) | 100% |

Lab

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| Final marks | Theory marks \* 0.75 + Lab marks \* 0.25 |

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| **17** |
| **Week** | **Topic** | **CLO** | **Taxonomy****Level** | **Specific Outcome** | **Contact Hours** | **Assessment** |
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| Chapter: 01 * Introduction to Magnetic Circuits
* Current
* Magnet and Magnetism
* Magnetic Field and Flux
* Relation between Magnetic flux density (B) and Magnetic field intensity (H)
* Reluctance and Permeance
* Ampere’s Circuital Law
* Magnetic Flux density for a long straight wire
* Calculation of Magnetic Flux Density in a Toroidal coil
* Related Examples
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 | CLO1  | C1, C2  | Students will be able to:* Understand the basic concepts of the general laws of mechanics, fields, waves, electromagnetism, and their application towards solving engineering problems.
* Knowledge and use of the principles of circuit theory and electrical machines.
 | 3+1 |  |
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| * Comparison between Magnetic and Electric Circuit
* Analysis of Air Gap in a Magnetic Circuit
* Force between two parallel conductors
* Magnetic Materials and B-H Curve
* Hysteresis Loop
* Related Examples
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 | CLO1  | C1  | Students will be able to:* Explain the various types of torques produced in electrical machines and Fundamental principles of operation of rotating electrical machines.
* Summarize definition and principles of magnetic circuits.
 | 3+1 | Quiz 1 |
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| Chapter : 02 * Transformer, its working principle and its construction
* Characteristics of Ideal Transformer
* E.M.F equation of a Transformer
* Turns ratio of transformer
* Related Examples
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 | CLO2  | C1, C4 | Students will be able to:* Identify the parameters of single phase transformer by test.
* Describe the principle of transformer and power losses.
* Provide knowledge different types of transformers.
* Describe the correlation between values of given quantities of primary and secondary (current, voltage) in terms of turns ratio and power, efficiency of a transformer.
 | 3+1 |  |
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| * Transformer at no Load
* Rules for Referring Impedance
* Transformer at Loaded Condition
* Equivalent Circuit of Transformer
* Related Examples
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 | CLO2  | C3, C4  | Students will be able to:* Describe reasons for losses and determine saturation point and core losses (eddy current and hysteresis).
* Describe effects of load to transformer performance.
* Describe the power transfer, the factors affecting the efficiency and state the meaning of polarity markings.
 | 3+1 |  |
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| * Voltage Regulation of a Transformer
* Efficiency of Transformer
* Transformer Tests
* Auto Transformer
* Three- Phase transformer
* Problem Solving Session
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 | CLO2  | C1, C3, C4 | Students will be able to:* Describe the construction and usage of autotransformer and determine the voltage and current relationship of an autotransformer.
* Describe the power transfer, the factors affecting the efficiency and state the meaning of polarity markings.
* Perform calculations of line and phase voltages and currents.
 | 3+1 | Assignment 1  |
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|  Chapter: 03 * Electromagnetic Induction
* Construction of DC Generator
* DC voltage output from DC Generator
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 | CLO2  | C2, C4  | Students will be able to:* Ability to calculate and design electrical machines.
* Knowledge of machine control and electrical drives and their applications.
 | 3+1 | Quiz 2 |
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| * Armature Winding
* Types of DC Generator
* Saturation Curve of DC Generator
* Generator Buildup Process
* Armature Reaction
* Related Examples
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 | CLO2  | C2, C3, C4  | Students will be able to:* To understand the operation of electrical machines.
* Compare the performance characteristics of different machines.
* To select the appropriate types of electric machines based on their characteristics and the specific application requirements.
 | 3+1 |  |
| 8 | * Cancellation of Armature Reaction
* Voltage Regulation of a DC Generator
* Losses of a DC Generator
* Problem Solving Session
 | CLO 2 | C2, C4  | Students will be able to:* Have knowledge of the operating and safety testing of electric machines.
* To understand the mathematical models and circuit models and how to determine corresponding parameters.
 | 3+1 |  |
| 9 | Chapter: 04 * Direct Current Motors & it’s working principle
* Back or Counter EMF
* Classification of DC Motor
* Mechanical Power of DC Motor
* Torque of DC Motor
* Speed Regulation of DC Motor
* Losses in DC Motor
* Related Examples
 | CLO 2   | C1, C2, C4 | Students will be able to:* To select the applications and how the machines are used.
* Prepare circuits for starting and speed control of DC machine and three phase induction motor.
 | 3+1 |  |
| 10 | * DC Motor Characteristics
* Efficiency of DC Motor
* Series, Shunt & Compound Motor Characteristics
* Comparison between generators & motors
* Application of DC Motors
* Problem Solving Session
 | CLO 2  | C1, C4  | Students will be able to:* Exploring the working of linear machine as generator, motor and transformer by applying basic electromagnetic laws on them.
* To select appropriate DC motor for specific purpose and compute their steady performance.
 | 3+1 | Quiz 3 |
| 11 | Chapter: 06 * Construction of Polyphase Induction Motor
* Types of Rotor & Skew Angle
* Working Principle of Induction Motor
* Rotating Field of a 3-phase Induction Motor
* Synchronous speed & Slip speed
* Rotor Voltage & Rotor Torque
* Related Examples
 | CLO 3 | C3, C4  | Students will be able to:* Provide knowledge on Construction and performance of salient and non – salient type synchronous generators.
* Provide knowledge on Construction, principle of operation and performance of single phase induction motors and special machines.
 | 3+1 |  |
| 12 | * Starting Torque
* Running Torque
* Relationship between different torques
* Equivalent Circuit
* Related Examples
 | CLO 3 |  | Students will be able to:* Provide knowledge on Starting and speed control of three phase induction motors.
* Compare and contrast the torque speed characteristics of motor.
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| 13 | * Power Relationships
* Power Stages in an Induction Motor
* Torque Slip Characteristics
* Linear Induction Motor
* Problem Solving Session
 | CLO 3 | C2, C3, C4 |  | 3+1 | Assignment 2  |
| 14 | Chapter: 08 * Introduction to Synchronous Generator
* Construction of Synchronous Generator
* Types of Poles
* Pole and Frequency
* Working Principle of Synchronous Generator
* Pitch and Short Pitch Winding
* Related Examples
 | CLO 3  | C2, C4  | Students will be able to:* Explain construction and operation principle of ac generators.
* Describe the factors affecting to the AC generator output.
* Describe the working principles and state the features of both field- and armature revolved generators.
* Describe the working principle of three-phase alternators.
 | 3+1 |  |
| 15 | * Chording Factor
* Distribution Factor
* Effects of Harmonics on Different Factors
* EMF Equation of an Alternator
* Related Examples
* Equivalent Circuit of a Synchronous Generator
* Phasor Diagrams and Voltage Regulation
* Tests of Synchronous Generator
* Power and Torque Expression
 | CLO 3 | C3, C4  | Students will be able to:* Describe wave forms and phase differences and state features, calculate phase and line voltage.
* Explain the construction, features and operation principle of AC motors.
 | 3+1 | Quiz 4 |
| 16 | * Equivalent Circuit of a Synchronous Generator
* Induction Motor working principle and characteristics
* Phasor Diagrams and Voltage Regulation
* Power and Torque Expression
* Revision
 | CLO 3 |  | * Explain the construction, features and operation principle of AC motors.
* Describe the working principle of single and polyphase type AC synchronous and induction motors and states the characteristics of them.
* Describe methods of speed control and direction of rotation.
* Describe the main methods of producing a rotating field in a capacitor, inductor, shaded or split pole.
 | 3+1 |  |

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| **18** | **Course Learning Outcomes (CLOs) and Assessment Plan** |
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| CLOActivity  | CLO 1 | CLO2 | CLO3 | CLO4 |
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| Quiz 1 | C2, C3 |  |  |  |
| Quiz 2 | C1, C3 |  |  |  |
| Assignment 1 | C1, C2, C4 |  |  |  |
| MID TERM EXAM | C2 | C1, C4 |  |  |
| Quiz 4 |  |  |  |  |
| Quiz 5 |  |  | C1, C2 |  |
| Assignment 2 |  | C1, C4 |  |  |
| FINAL TERM EXAM | C1 | C1, C2, C4 | C1, C2 |  |
| Lab Final Exam |  |  |  | P1,P2, P3 |

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| **19** | **Lab Details** |
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| **Laboratory Resources** |
| * IC and trainers
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| **Computer Resources** |
| * Software based (Xilinx ISE)
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| **20** | **Mapping of CLOs to PLOs**  |

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| PLOCLOs | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 |
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| CLO1 |  |  |  |  |  |  |  |  |  |  |  |  |
| CLO2 |  |  |  |  |  |  |  |  |  |  |  |  |
| CLO3 |  |  |  |  |  |  |  |  |  |  |  |  |
| CLO4 |  |  |  |  |  |  |  |  |  |  |  |  |

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| **21** | **List of Experiment With Objectives as Per OBE Format**  |
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| **Sr. #** | **Experiment** |
| 1 | To study the voltage regulation for a single phase transformer using resistive load. |
| 2 | Calculation of the transformer parameters usingOpen Circuit Test & Short Circuit Test. |
| 3 | To record the magnetization characteristic, of a separately excited DC generator. |
| 4 | To record the terminal characteristics of a separately excited dc generator (Keeping IF constant). |
| 5 | To record the magnetization characteristic, of a self-excited DC shunt generator. |
| 6 | To record the terminal characteristic, of a self-excited DC shunt generator. |
| 7 | To record the magnetization characteristic of a DC series generator. |
| 8 | To record the load characteristic of a DC series generator. |
| 9 | To record the Load characteristics of dc series motor. |
| 10 | To record the Load characteristics of separately excited dc shunt motor. |
| 11 | To record Speed Control analysis of universal motor. |
| 12 | Record the magnetization characteristics of a 3 phase alternator. |
| 13 | To record voltage variation at the alternator terminal, for balanced resistive loads (Y- connected). |

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