University of Sargodha
College of Engineering and Technology
Department of Electrical Engineering

# Course Syllabus
# ET215: Electrical Machines-I

## Semester / Session: 3rd (Fall-2010) / 2019-2023

**Instructor:** Dr. Ateeq-Ur-Rehman Shaheen
Room: New Block, Ground Floor
Phone: +92-307-0166737
E-mail: ateeq.shaheen@uos.edu.pk

**Office Hours:** 0800hrs to 1600hrs

**Course TA:** N.A.

**Course Description:** This course is intended to provide a basic introduction to the theory of magnetic circuits linked with transformers and rotating electrical machines. The principles of electromechanical energy conversion will be discussed in the context of DC machines. In depth analysis of DC generators and motors will be carried out for different characteristics.

**Catalog Data:**

| | |
|---|---|
| Course Code: | ET-215 |
| Course Title: | Electrical Machines-I |
| Credit Hours: | 4 |
| Course Designation: | Engineering Technology Foundation |
| No of Sessions per week: | 2 (Total 32 sessions) |
| Session Duration: | 90 min |

**Catalog Description:** **ET-215 Electrical Machines-I, Credits (4)**
**Electromagnetic Induction and Basic Concepts in Rotating Machines:** Introduction to magnetic circuits, magnetically induced e.m.f. and force, AC operation of magnetic circuits, Hysteresis and Eddy current losses. Magnetic fields in rotating machines, generated voltages, torque. **DC Generators:** Constructional features and principle of operation, EMF equation, excitation types, load and no-load characteristics, commutation, armature reaction. **DC Motors:** Principle of operation, back e.m.f., torque equation, types of DC motors, speed-torque characteristics, speed control, applications. **Transformers:** Principle of operation, constructional features of single and three phase transformers, EMF equation, transformer on no-load and load, three phase transformer connections, auto- transformers. **Testing of DC Machines and Transformers:** Losses and efficiency, testing of DC machines and different types of tests

**Prerequisite:** NIL

**Prerequisites by Topics:** NIL

**Prepared by: Dr. Ateeq-Ur-Rehman Shaheen** **Date: Oct. 12, 2020**
**Signature: _____**

**Co-requisite:** NIL

**Textbook:** **Stephen J. Chapman** "Electric Machinery Fundamental", 5th Edition, McGraw- Hill International Edition.

**References:**

1. A.E. Fitzgerald, "Electric Machinery", 6th Edition, McGraw-Hill International Edition.
2. Charles I. HUBERT, "Electric Machines: Theory, Operating Applications, and Controls", 2nd Edition, Prentice Hall, 2001.
3. J. R. Hendershot Jr. and T. J. E Miller, "Design of Brushless Permanent-Magnet Motors", 1994
4. Hindmarsh, "Electrical Machines", McGraw-Hill. (Latest Edition)

**Program Learning Outcome:** This course is designed in conjunction with the following PLOs.

**PLO 1. Engineering Knowledge:** An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

**PLO 2. Problem Analysis:** An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

**Course Learning Outcome (CLO):** Upon successful completion of this course, the student will be able to:

**CLO 1.** Apply the concepts of magnetic circuits for the performance evaluation of electrical machines [Cognitive-Level 3 (Applying)]

**CLO 2.** Evaluate the operation and characteristics of DC machines. [Cognitive-Level 5 (Evaluating)]

**CLO 3.** Analyze the performance of transformers and three phase machines. [Cognitive-Level 5 (Evaluating)]

**Mapping of CLOs to PLOs and Learning Domains:**

| Course Learning Outcome | Program Learning Outcome | Learning Domain & Level |
|---|---|---|
| CLO-1 | PLO-1 | Cognitive-Level 3 (Applying) |
| CLO-2 | PLO-2 | Cognitive Level 5 (Evaluating) |
| CLO-3 | PLO-2 | Cognitive Level 5 (Evaluating) |

**Course Professional Outcome/ Industrial Usage:**

This course is an introductory course on Electrical Machines. It is designed for students in electrical engineering Technology. It introduces students to the types, working, characteristics, analyses and problems that may arise within the context of DC Electrical Machines. It also equips the students with fundamental concepts and analyses skills to evaluate DC Machines.

**Course Outline and Sessions Breakdown:**

**I. Electromagnetic Induction and Basic Concepts in Rotating Machines: (CLO-1)**
**(05 Sessions)**
Introduction to magnetic circuits, magnetically induced e.m.f. and force, AC operation of magnetic circuits, Hysteresis and Eddy current losses. Magnetic fields in rotating machines, generated voltages, torque.

**II. DC Generators (CLO-2)**
**(03 Sessions)**
Constructional features and principle of operation, EMF equation, excitation types, load and no-load characteristics, commutation, armature reaction.

**III. DC Motors (CLO-2)**
**(03 Sessions)**
Principle of operation, back e.m.f., torque equation, types of DC motors, speed-torque characteristics, speed control, applications.

**IV. Transformer (CLO-3)**
**(03 Sessions)**
Principle of operation, constructional features of single and three phase transformers, EMF equation, transformer on no-load and load, three phase transformer connections, auto- transformers.

**V. Testing of DC Machines and Transformers: (CLO-3)**
**(02 Sessions)**
Losses and efficiency, testing of DC machines and different types of tests

**Computer Usage:** Not applicable unless otherwise stated.

**Projects / Design Activities:** NIL

**Evaluation Criteria:**

| | | |
|---|---|---|
| **1.** Assignments (≥2) | 7.5% | CLO1 – CLO2 |
| 2. Quizzes (≥3) | 20% | CLO1 – CLO2 |
| 4. Mid-Term Exam | 20% | CLO1 – CLO2 |

**Prepared by: Dr. Ateeq-Ur-Rehman Shaheen** **Date: Oct. 12, 2020**
**Signature: _____**

| | | |
|---|---|---|
| 5. Final Exam | 50% | CLO1 – CLO3 |

## Policies

(a) No makeup tests or quizzes, except in case of emergency, e.g. illness and accident. For makeup tests, medical certificate is required and the instructor must be notified in advance of the test.
(b) No late assignment will be accepted.
(c) Topics and schedule mentioned here are tentative. They may be slightly changed depending on the interest / pace of class.
(d) **Class notes and Handouts:**

Students must take notes in the class. Equations, expressions and problems would be copied from the board as the instructor writes while, the student should note down important points as the instructor delivers the lecture both as orally and through slides. This body of material would form the most important asset of the student for exam preparation and in obtaining good grades.

Additional study material supplementing the class notes is the text book. The student must always inculcate the habit of book reading for deepening and strengthening the concepts gained in the class.

(e) **Attendance Policy:**

Class attendance is mandatory. You are expected to be present in all classes. The students having their attendance less than 75% will not be allowed to appear in the exam and will be awarded "F" grade hence forth.

(f) **Homework Policy:**

- **You SHOULD NOT** copy homework from classmates. You may consult with the instructors or one of your classmates if there is a homework problem that you find difficult.
- Copying assignment will not carry any benefit because quizzes will be based on assignments and most of the assignments will be marked based on quizzes.
- Late homework is not accepted for any reason.
- Homework papers should have a cover page showing name, ID number, date, problem number and assignment number.
- Class serial number should appear on the top right hand corner of the cover page.
- All problems in an assignment set should be arranged sequentially.
- A4 Paper should be used for Assignments.

(g) **Quizzes:**

These will be held promptly on the designated day. They will cover the material taught the previous weeks. Late arrival or non-attendance without a legitimate excuse will mean that you are ineligible to take that quiz.

(h) **Academic Dishonesty:**

The UOS is an academic community whose purpose is the pursuit of knowledge and the development of its graduates as leading experts in their academic disciplines. All members of this community must be committed to the principles

of truth and academic honesty. Academic dishonesty includes the following acts committed knowingly or intentionally by the student:

- **Cheating:** Using or attempting to use unauthorized materials and assistance, such as notes, study aids, electronic communication devices of any sort, or any other forms of unauthorized information or consulting any unauthorized sources, in any academic assignment, exercise, or examination.
- **Fabrication**: Falsifying or inventing research, citations, or any information on any academic assignment, exercise, or examination.
- **Plagiarism:** Representing another's words or ideas as one's own or failing to give proper credit to outside sources of information in any academic assignment, exercise, or examination.
- **Facilitating academic dishonesty:** Aiding or assisting another in cheating, fabrication or plagiarism.

Students who have committed an act of academic dishonesty are subject to one or more of the following penalties:

- A written warning
- A reduction in grade for the assignment
- A zero grade for the assignment
- A reduction of grade for the course, including an **F** grade for the course.
- Suspension from the Wah Engineering College for one or more semesters.
- Expulsion from the Wah Engineering College.

Records of incidents of academic dishonesty will be kept on file at the Wah Engineering College and may be reported to the student's guardian and sponsor.

Students who are in doubt about whether certain academic activities are honest or not should discuss the matter with the course instructor or consult the WEC policy on academic integrity.

**Disclaimer:**

(i) The instructor reserves the right to change, and adjust the policies and class schedules at any time during the semester.

**COURSE DISTRIBUTION ON WEEKLY BASIS**

| Weeks | Topics | Quiz/ Assignment |
|---|---|---|
| **WEEK 01 TO WEEK 05** | **Introduction to Magnetic Circuits** | CLO-1 Chapter 1 (Chapman & Fitzgerald) |
| **WEEK 06** | **DC Generator:** Construction, Types of DC generators, separately excited generator, shunt generator, voltage build-up phenomenon, series generator, compounded generator and its type; under compounded, over compounded and flat compounded generator, terminal characteristics of all the | CLO-2 (Chapman 7.3, 7.4 and Lecture Notes)<br>Assignment 1 |

| | | |
|---|---|---|
| | generators. | |
| **WEEK 07** | **Armature Reaction:** 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). | CLO-2 (Chapman 7.4 and Lecture Notes)<br><br>Quiz 1 |
| **WEEK 08** | **Commutation:** One Commutation process, commutation time, ideal commutation, poor commutation, effects of poor commutation, practical difficulties, Ldi/dt effect, interpoles, function of interpoles.<br>**Losses:** Different types of losses and their formulation, power flow diagram of motor and generator, calculation of maximum efficiency, calculation of losses at different loads circuit. | CLO-2 (Chapman 7.4, 7.7 and Lecture Notes) |
| **WEEK 08** | **Mid-Term** | CLO1-CLO2 |
| **WEEK 09 to WEEK 10** | **DC Motors**: Working principle, construction and operation, different types of DC motors, Back e.m.f equation, torque equation, terminal characteristics of separately excited and shunt type DC motor. Series and parallel combinations | CLO-2 (Chapman 8.1 to 8.4) |
| **WEEK 11** | **Speed Control of DC Motor:** Base speed, speed control of DC motors especially shunt type and separately excited machine, voltage control method, field current control method, effects of open field, permanent magnet machines. | CLO-2 (Chapman 8.4 to 8.5) |
| **WEEK 11** | **DC series motor:** Expression for torque, applications, terminal characteristics, methods for speed control. | CLO-2 (Chapman 8.6) |
| **WEEK 12 to WEEK 13** | **Transformer:** Basic principal and operation, types and construction, applications, ideal and practical transformer and their comparison; voltage and current transformation, impedance matching, dot convention. | CLO-3 (Chapman 2.1 to 2.4) |
| **WEEK 14** | **Auto Transformers:** Basic principle, construction and | CLO-3 (Chapman 2.9 and |

| | | |
|---|---|---|
| | working, voltage and current relationship, apparent power rating advantage of auto transformers.<br>**Three phase transformers:** Types, ratings, different type of connections. | Lecture Notes) |
| **WEEK 15** | **Losses:** Different types of losses and their formulation, power flow diagram of motor and generator, calculation of maximum efficiency, calculation of losses at different loads circuit. | CLO-2<br>(Chapman 7.4, 7.7 and Lecture Notes) |
| **WEEK 16** | **Transformer Tests and Voltage Regulations:** Open circuit Test and calculations of magnetizing branch parameters, short circuit test and calculation of impedance, Voltage regulation, reasons of voltage drops, and voltage regulation under different load conditions. | CLO-3<br>(Fitzgerald 2.5 and Chapman 2.7 and 2.8) |
| **WEEK 17** | Revision | |
| **WEEK 18** | **Final Examination** | CLO-1 to CLO-3 |