NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
MECHANICAL-ELECTRICAL ENGINEERING PROGRAM

ML244 – ROTATING ELECTRICAL MACHINES

I. GENERAL INFORMATION

CODE	**:**	ML244 Rotating Electrical Machines
SEMESTER	**:**	7
CREDITS	**:**	4
HOURS PER WEEK	**:**	6 (Theory–Practice-Laboratory)
PREREQUISITES	**:**	ML214 Static Electrical Machines,
CONDITION	**:**	Compulsory
DEPARTMENT	**:**	Mechanical - Electrical Engineering

II. COURSE DESCRIPTION

The course prepares students in the analysis and operation of DC and AC machines. Students understand the principles of operation, constructive and physical aspects, generator and motor behavior at stable regimen, efficiency and power losses. Students also analyze and apply the synchronous machine, understand its physical and constructive aspects, analyze the multi-phase asynchronous machine in stable regime, single-phase machines, as well as the physical and constructive aspects of AC motors.

III. COURSE OUTCOMES

At the end of the course, students:

1. Understand the principles of operation of DC and AC rotating machines.
2. Apply concepts of magnetic circuits with ferromagnetic cores to solve problems of rotating machines.
3. Solve circuital models of AC and DC generators and machines to determinate the electrical parameters.
4. Describe the constitution and components of AC and DC machines and generators, and explain their functioning principles.
5. Understand and apply safety regulations to prevent accidents at working with electricity.

IV. LEARNING UNITS

1. PRINCIPLE OF OPERATION OF DC MACHINES

Principles of operation / Magnetic field produced by the stator / Determination of generated EMF / Function of the switch / Magnetic field produced by the rotor / Switching and interpoles Compensation windings / Electromagnetic torque / Problems.

2. PHYSICAL APPEARANCE AND CONSTRUCTION OF DC MACHINES

General information / The poles / Field coils / Interpoles / Compensation windings / The yoke of stator / Brushes and brush holders / Armature core / Switching / Armature windings / Problems.

3. DC GENERATOR AT STABLE REGIMEN

Generator equivalent circuit / Generator equations at stable regimen / Types of generators / Curves of generators / DC generators in parallel connection / Problems.

4. DC MOTOR AT STABLE REGIMEN

Motor equivalent circuit / Motor equations at stable regimen / Types of motors / Power regulation of DC motors / Curves of the motor / Starting current and torque / Comparison of the characteristics of shunt, series and compound motors / DC motor speed control methods / Reverse direction of rotation of DC motors / Electric braking. / Manual and automatic devices for starting DC motors / Electronic control of DC motors / Problems.

5. **EFFICIENCY AND POWER LOSSES IN DC MACHINES**
   Efficiency / Losses / Power balance of DC machines / Conventional efficiency / Problems.
6. **PRINCIPLES OF OPERATION OF THE SYNCHRONOUS MACHINE**
   General considerations / Magnetic fields of rotor and stator / Electromagnetic torque / Generation of EMF / Distribution and step factors / Equations to determine the EMF / Considerations in the operation of synchronous machines / Problems.
7. **THE SYNCHRONOUS MACHINE AT STABLE REGIMEN**
   The cylindrical rotor machine / Synchronous reactance of cylindrical rotor machines / Equations and phasor diagram / Internal characteristics of the synchronous machine / Under-load features of the synchronous machine / Power-angle equation of the synchronous machine of cylindrical rotor / Salient-pole machine / Efficiency / Self-excitation of synchronous machines / Operation of synchronous motor. / Parallel operation of synchronous generators / Problems.
8. **PHYSICAL ASPECTS AND CONSTRUCTION OF THE SYNCHRONOUS MACHINE**
   General considerations / The rotor / The stator / Winding of armor / Forms of excitation / Ventilation and cooling of the alternators / Problems.
9. **THE MULTI-PHASE ASYNCHRONOUS MACHINE AT STABLE REGIMEN**
   Principle of operation / MMF waves and resulting flows / Equivalent circuit / Equation of induction motor / Maximum torque / Double squirrel cage motors / Standard curves / Starting of three-phase induction motor / Electrical braking / Efficiency and losses / Numerical examples / Problems.
10. **SINGLE-PHASE ENGINE**
    General considerations / Single phase induction motor / Universal motor / Hysteresis motor / Reluctance motor / Sub-synchronous motor / Regulation motor / Problems.

V. PRACTICAL EXPERIENCE

Practice 1: DC machines.
Practice 2: Synchronous machines.
Practice 3: Asynchronous machines.
Practice 4: Single-phase engines.

VI. METHODOLOGY

The course takes place in theory and practice sessions. In theory sessions faculty presents the theory, concepts and methods. In practice sessions, students apply theory to solve diverse problems related to DC and AC generators and motors. At the end of the course, students submit and defend a final report. Student active participation is promoted throughout the course.

VII. GRADING FORMULA

The Final Grade PF is calculated as follow:

PF = (EP + 2*EF + PP) / 4

EP: Mid-term Exam EF: Final Exam
PP: Average of practice grades.

VIII. BIBLIOGRAPHY

1. FITZGERALD.
   Electrical Machinery.
2. SISKIND
   Direct Current Machinery.
3. KIMBARK
   Power Systems Stability, Vol. 3.