NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING
MECHANICAL ENGINEERING PROGRAM

ML202 – ELECTRICAL MACHINES

I. GENERAL INFORMATION

CODE	: ML202 Electric Machines
CYCLE	: 5
CREDITS	: 4
HOURS PER WEEK	: 6 (Theory– Practice - Laboratories)
PREREQUISITES	: ML140 (Electric Circuits)
CONDITION	: Mandatory

II. COURSE SUMMARY

Electrical Machines is an Applied Engineering that studies the different types of electrical machines, both Static and Rotary: transformers, autotransformers, motors and generators, of continuous and increasing use in our modern industrialized society.

In this context, the subject motivates the learning of ferromagnetic materials, circuit models, technical standards and the selection of industrial electrical machines.

III. COURSE OUTCOMES

The students:

1. Calculate the parameters of ferromagnetic materials, CD and AC magnetic circuits, used in industry through the theory implemented in class, models and technical standards.
2. Solve different cases using single-phase power transformers and autotransformers, three-phase industrial transformers, through the theory implemented in class, models and technical standards.
3. Will solve different cases using rotary electric machines: industrial induction motors, through the theory implemented in class, models and technical standards.
4. Solve different cases using industrial direct current rotary electric machines, using the theory implemented in class, models and technical standards.

IV. LEARNING UNITS

1. ENERGIZED FERROMAGNETIC STRUCTURES WITH CONTINUOUS CURRENT AND ALTERNATIVE CURRENT / 8 HOUR.

Fundamentals of magneto statics. Magnetic properties of materials. Law of Ampere in magnetic media. Ferromagnetic materials. Concept of magnetic circuit and its analogy with electrical circuits. Magnetic circuits series of constant rectangular section with and without air gap. Problems. Magnetic circuits parallel of rectangular section with and without air gap. Magnetic circuits of different sections. The iron core reactor and its operation with alternating current. Faraday's Law of Electromagnetic Induction. Loss of energy in the ferromagnetic nucleo. Separation of losses. Excitation current of a coil with ferromagnetic core. Determination of the equivalent circuit parameters. Problems.

2. THE TRANSFORMER. THE POWER SINGLE PHASE AUTOTRANSFORMER. THREE-PHASE TRANSFORMERS / 10 HOURS

Key features of the construction and operation of the single-phase power transformer. The exact equivalent circuit. Approximate equivalent circuit. Phasor diagrams of the real single-phase transformer operating under vacuum and under load. Laboratory tests and determination of their parameters. Analytical determination of regulation. Efficiency and maximum performance. The single-phase power transformer used in a power system. The single-phase power autotransformer: operating principle; Circuit equivalent phasor diagrams. The single-phase transformer used as an autotransformer. Single-phase transformer banks and three-phase transformers. Types of connections: The triangle-triangle connection. The star-star connection. The star connection - Triangle. The triangle-star connection. Equivalent circuit of a three-phase transformer. Vacuum and short-circuit tests of a three-phase transformer and determination of its parameters. The connection in open delta or in V / v. Problems.

3. ROTARY ELECTRIC MACHINES THE INDUCTION ENGINE IN STABLE REGIME / 12 HOURS.

Rotary electric machines: general, definition of generator and motor. Constructive aspects of a rotary electric machine. Basic principles of the electromechanical conversion of energy: Principle of the generator and principle of the engine. AC electric machines: general, types. The three-phase induction motor: classification, constructive aspects of stator and rotor. Rotating magnetic field in the three-phase induction motor. Principle of operation of the three-phase induction motor. Rotary magnetic field produced by the rotor. Requirements to be met by the rotor for the correct operation of the asynchronous motor. Circuit model with rotor in motion: exact equivalent circuit in steady state, approximate equivalent circuit. Determination of the parameters of the circuit model of the induction motor by laboratory tests: Tests with locked rotor and vacuum. Balance of powers in the induction motor. Efficiency. Torque or rotation torque of the three-phase induction motor: useful torque, developed torque or motor torque. Characteristic curve of the developed torque of the motor as a function of the slip. Behavior of the motor with load coupled to the shaft. Expression of the torque according to the parameters of the circuit model. Boot torque. Maximum torque. Types of operating regimes of the three-phase motor. Types of induction motor starting. Forms of speed control of the induction motor. Selection of induction motors. problems

4. ELECTRICAL MACHINES OF CONTINUOUS CURRENT IN STABLE SCHEME / 12 HOURS

The electric machine of direct current or machine DC: constructive aspects. Main magnetic field in the air gap. DC machine operating as generator: Voltage waveform generated by DC elementary machine. Armature winding of a real DC machine. Expression of the voltage generated in an actual DC machine. Circuit model of DC generator in steady state. DC generator operating under load. DC machine operating as a motor. Circuit model of the DC machine operating as a steady state motor. Real motor: expression of the developed torque. Types of DC machines as generator and motor: Circuit model in steady state of self-excited DC machines; Shunt type DC machine; DC type machine and DC type compound machine. Problems. Internal characteristic curve or curve of magnetization of the DC machine. Self-excitation of the shunt generator. Power flow in DC generator: efficiency. Power flow in DC motor: efficiency. Output characteristics of DC generators: voltage regulation. Output characteristic curves for DC motors: speed control. Problems.

V. LABORATORIES Y PRACTICAL EXPERIENCES.

- First Laboratory: Iron Core Reactor
- First Qualified Practice
- Second Laboratory: Single-phase power transformer.
- Second Qualified Practice
- Third Laboratory: induction motors.
- Third Qualified Practice.
- Fourth Laboratory: DC motor.
- Fourth Qualified Practice.

VI. METHODOLOGY

The method used in the Electrical Machines course is Problem Based Learning (ABP). The problems proposed in the works are:

Laboratories, Qualified Practices and real work in equipment: three-phase power transformer powering an induction motor and a DC motor of an Industry.

VII. GRADING FORMULA

The following formula will be used, to calculate de final grade.

NF = FINAL GRADE,

NU1 = UNIT I GRADE,

NU2 = UNIT II GRADE,

NU3 = UNIT III GRADE,

NU4 = UNIT IV GRADE,

FINAL GRADE =NF**=** $\frac{0{,}15NU1 + 0{,}15NU2 + 0{,}2NU3 + 0{,}5NU4}{1}$

VIII. BIBLIOGRAPHY

• E.E. STAFF. MIT. "Magnetic Circuits and Transformers". Editorial Reverté. Argentina (2003)

• IRVING L. KOSOW Ph. D. "Electric Machinery and Transformers". (2 Matches)

• THEODORE WILDY "Power Machines and Power Systems". University Labal. Mexico (6th Edition) (2007).