Electromagnetics

Academic Year: (2019 / 2020) **Review date: 06-05-2020**

Department assigned to the subject: Physics Department

Coordinating teacher: LOPEZ MARTINEZ, FERNANDO

Type: Electives ECTS Credits : 6.0

Year : Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Calculus I
Calculus II
Physics II

OBJECTIVES

Knowledge and ability to handle with classical electromagnetism laws in differential and time-dependent formalisms (Maxwell equations). As well as in stationary and integral forms.
Understanding the relationship between electromagnetic field and its sources: charges and currents.
Being able to apply the equations for the development of simple physical models of high symmetry
Ability to formulate and solve electromagnetic problems in direct mode: How to charges and currents generate EM fields and the effects of EM field on charges and currents.
Understanding the effect of media on the EM field and the boundary conditions between two media.
Understanding how the temporal variation of the electric and magnetic fields are in turn sources of electromagnetic field
Understanding of electromagnetic waves, as a particular solution of the electromagnetic field generated by oscillating sources
Understanding the basic concepts of Wave Optics as an extension of Electromagnetic Waves at optical frequencies.
Summarising, the ability to understand the fundamentals of most phenomena and applications based on electromagnetism.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to Electromagnetism. Review of previous concepts
1.1 Introduction to the topic
1.2 Scalar sources of Fields. The divergence. Divergence theorem
1.3 Vector sources of Fields. The curl. The Stokes theorem

2. Maxwell equations of Electromagnetic field in vacuum.
2.1 Irrotational and solenoidal fields. The Helmholtz`s theorem.
2.2 Scalar and vector Sources of EM field
2.3 Axiomatic presentation Maxwell's equations in vacuum.

ELECTRIC FIELD

3. The Electrostatic Field in Vacuum
3.1 Sources of Electrostatic Field. Charge distributions. The Electric Potential
3.2 Integral Equations. Gauss`s Theorem.
3.3 Poisson and Laplace equations
3.4 Analytical and numerical methods for problem solving in Electrostatics.

4. The electric field in presence of materials

4.0 Introduction to Electrical Properties of Matter. Fundamentals of Electrical Conduction
4.0.1 Electrical properties of matter. Electrical Conduction. Types of conduction.
4.0.2 Conduction in solids. Typical magnitudes
4.0.3 Generalized Ohm's Law. Joule effect in differential form

4.1. Electric Field and Conductors in electrostatic equilibrium
4.1.1 Properties of conductors in electrostatic equilibrium

4.1.2 Systems of Conductors. Capacitors
4.1.3 Problems solving with conductors in electrostatic equilibrium. The method of images.

4.2. Electric Field and Dielectrics
4.2.1 Polarization of Matter. Electric polarization vector P. Polarization charges
4.2.2 Electric Displacement Vector D. Sources of D: div D and rot D
4.2.3 Constitutive relations in the electric field. Electric Permittivity. Boundary Conditions
4.2.4 Nonlinear dielectrics. Ferroelectricity. Fundamentals and Applications

5 Energy and Force in the Electric Field
5.1 Electric energy of charge distributions
5.2 Energy density in electric field.
5.3 Forces and torques on conductors and dielectrics. Electrostatic pressure

MAGNETIC FIELD
6 Magnetostatics in vacuum and non-magnetic media
6.1 Scalar and vector sources of Magnetic Field. Ampère`s differential law
6.2 The Magnetic Vector Potential A
6.3 Biot-Savart`s law. Circuital law. Magnetic forces and torques

7. The Magnetic Field in Magnetic Media
7.1 Magnetization. Sources of M. Matter in presence of magnetic field
7.2 Magnetic field vector H. Its sources. Constitutive relations in the magnetic field. Magnetic permeability. Boundary conditions for magnetic vectors
7.3 Introduction to Ferromagnetism. Curie temperature. Spontaneous magnetization Ferromagnetic domains. The hysteresis cycle

Time dependent EM fields

8. Electromagnetic Induction
8.1 Faraday`s flux rule and exceptions
8.2 EM induction by temporal variation and in moving systems. Induced Electric field and induced current
8.3 Expressions of energy in terms of magnetic flux and magnetic potential. Energy density in magnetic field

9. The Ampere-Maxwell law and Maxwell's Equations
9.1 Vector sources of magnetic field. Displacement current
9.2 Maxwell¿s equations of electromagnetic field in matter.
9.3 Fundamental equations of Electromagnetism.

10. Electromagnetic Waves
10.1 The Wave Equation of EM Field. Plane Wave Solutions. Complex formulation
10.2 Wave parameters: amplitude, spatial and time frequency, wavelength, period, propagation velocity, refractive index
10.3 Power and Intensity of EM waves. The Poynting¿s Vector

11. Introduction to Wave Optics
11.1 The electromagnetic spectrum. Properties. Addition of simple waves.
11.2 Beats. Phase and group velocity. Propagation in dielectric media.
11.3 Wave phenomena: Polarization, Interference, Diffraction.
11.4 Interaction light-matter: absorption and emission of EM radiation

LEARNING ACTIVITIES AND METHODOLOGY

Lectures, where the theoretical concepts are explained
The lecturer will provide with the following information (1 week in advance)
- Main topics to be discussed during the session (short description)
- Chapters/sections in each of the text books provided in the bibliography where the student can read about these topics

Activities in small groups to solve problems, in order:
- To understand the statement of the problem by means of, for instance, simple drawings and schemes
- To identify the physical laws involved.
- To develop a problems solving strategy to reach the objective (by simplification, studying similar problems already solved, using methods coming from other parts (magnetostatic problems using electrostatic methods,¿)

- Training in mathematical skills
- To analyze the reasonability of the result (order of magnitude, dimensional analysis,¿
- To search scientific information in internet.

ASSESSMENT SYSTEM

50% of final mark is obtained in the written end-of-term exam, consisting of 2 parts (25% + 25%) corresponding to both parts of the topic. Contents: Problems to be solved, short conceptual questions and multiple choice questions.

The remaining 50 points correspond to continuous assessment in 2 notes for both parts alike. The student may apply for up to 20 points out of these 50 (10 per each part), in personal works with individual presentations on topics proposed by the professor.

In case of this mark being (>=10%) in one or in both parts, the student can choose for trespassing the mark to the final exam, in a relationship of 25 to 20. Nevertheless the student can always apply for the end-of term exam. In this case the corresponding mark in this exam will prevail.

% end-of-term-examination:	50
% of continuous assessment (assigments, laboratory, practicals…):	50

BASIC BIBLIOGRAPHY

- David K. Cheng Fundamentals of Engineering Electromagnetics, Prentice Hall, latest edition
- J.R. Reitz, F.J. Milford, R.W. Christy Foundations of Electromagnetic Theory, Addison-Wesley, Latest edition
- Joseph A.Edminister, Mahmood Nahvi-Dekhordi Schaum's Outline of Electromagnetics, McGraw-Hill. , Latest edition
- Wangsness, R.K. Electromagnetic Fields, John Wiley & Sons Inc., Latest Edition

ADDITIONAL BIBLIOGRAPHY

- John D. Kraus Electromagnetics, McGraw-Hill, Más reciente
- P. Lorrain, D.R. Corson, Lorrain Electromagnetic fields and waves, Freeman, Más reciente