UNICUSANO ROME

Code: ING-INF/02 **Credits:** 9
Matter: Electromagnetic Fields
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor

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Introduction

1. *Objective of the course :*
   The main objective of the course is to provide the basic knowledge of electromagnetism. Particular emphasis will be given to the engineering aspects for the analysis and design of simple electromagnetic systems oriented to applications in electronics and telecommunications.

Objectives

2. *Course Structure:*
   The course is divided into five parts. In the first part, we recall some fundamental concepts of mathematics and geometry. In the second part, the fundamentals of Maxwell's electromagnetic theory are provided. The third part deals with the propagation of plane waves in unlimited media and at the interface between two different media. In the fourth part, we discuss the transmission line model and the matching-related problems. Finally, in the fifth part, we introduce the basic concepts of electromagnetic radiation.

Competencies:

A. Knowledge and understanding.

At the end of the course, the student will have knowledge of the electromagnetic waves theory and of the fundamental physical principles for their generation, propagation and reception. In particular, the student will be able to understand the implications of Maxwell's equations (in both integral and differential form) in the

study of transmission lines, plane-wave and guided-wave propagation, and radiation phenomena.
In addition, through the E-tivities, the students will be able to formulate electromagnetic problems within the software CST Microwave Studio (student edition).

B. Applying knowledge and understanding.
The student will be able to use electromagnetic theory and related analytical tools to build simplified models of electromagnetic problems, with particular reference to the context of transmission lines, waveguide propagation and electromagnetic radiation. He will be also able, by using these models, to evaluate and quantify the required quantities.

C. Making judgements.
The student will be able to identify the most appropriate models to describe the single functional blocks of a complex electromagnetic system (e.g. generator, transmission line, radiating element) and to apply critical verification methods of the results obtained.

D. Communication skills.
The student will be able to describe and have technical conversations on physical/mathematical models for the analysis of applications based on the propagation of electromagnetic waves, correctly identifying the relevant physical quantities and using appropriate terminology.

E. Learning skills.
At the end of the course, the student will have knowledge of the electromagnetic theory and the related analysis techniques, and will be able to distinguish between the lumped-parameter circuit approach (typical of electrical engineering), the distributed parameters approach, or the one based on the use of electromagnetic fields. This will allow him to continue his engineering studies with greater maturity and will provide him with the basis to approach the specialized courses of electromagnetism (e.g. antennas and microwaves).

Syllabus

3. *Programme of the course:*

First Part

Elements of mathematics and geometry (complex number; matrix algebra; vectors; scalar and vector fields; coordinate systems).

Second Part

Maxwell equations and fundamental theorems (fundamental equations of the electromagnetic field; boundary conditions; complex notation and complex vectors; polarization of a vector field: linear, circular, elliptical; fundamental theorems; constitutive relations and electromagnetic properties of materials).

Third Part

Waves equation and corresponding solution in canonical reference systems. Plane waves (homogeneous Helmholtz equation; wave functions; plane waves; general properties of plane waves; non attenuated uniform plane wave; plane wave non-uniform perpendicular attenuated to the direction of propagation; attenuated uniform plane wave; spectrum of plane waves; not monochromatic plane waves: group velocity of a wave packet; reflection and transmission of plane waves by a flat interface: normal incidence; reflection and transmission of plane waves by a flat interface: oblique incidence; total reflection and Brewster angle).

Fourth Part

Transmission lines: introduction on transmission lines; transmission lines equations; traveling and stationary waves; impedance and admittance of the line; characteristic impedance and propagation constant; input impedance; reflection coefficient and standing wave ratio; matching of a transmission line, quarter-wave transformer, matching problems; abacus of Smith.

Fifth Part

Electromagnetic radiation. Green's function for free space. Electromagnetic potentials. Hertz dipole. Introduction to the antennas.

Evaluation system and criteria

The exam consists in a written test and a series of activities (E-tivity) carried out during the course in virtual classrooms.

The evaluation of the E-tivity, from 0 to 5 points, is carried out during the duration of the course. The exam is evaluated for the remaining from 0 to 25 points.

The written test (lasting 90 minutes) requires the theoretical discussion of two topics of the course. Each answer will be evaluated on the basis of the following aspects: relevance to the question, completeness of the information, development method of the topic.

Bibliography and resources

4. *Materials to consult:*
   The material on the platform is divided into 6 modules. They cover the entire program and each of them contains handouts, slides and video lessons in which the teacher comments on the slides. This material contains all the elements necessary to deal with the study of the course.

5. *Recommended bibliography:*

   - *Markus Zahn, Electromagnetic Field Theory: A Problem Solving Approach. (Massachusetts Institute of Technology: MIT OpenCourseWare). http://ocw.mit.edu*
   - *Electromagnetic Waves and Antennas by S.J. Orfanidis (http://www.ece.rutgers.edu/~orfanidi/ewa/)*