UNIVERSITÀ DEGLI STUDI DI PALERMO

SCHOOL	POLYTECHNIC SCHOOL
ACADEMIC YEAR	2016/2017
FIRST CYCLE COURSE	BIOMEDICAL ENGINEERING
SUBJECT	ELECTROMAGNETIC FIELDS FOR BIOENGINEERING
TYPE OF EDUCATIONAL ACTIVITY	D
AMBIT	10437-A scelta dello studente
CODE	18451
SCIENTIFIC SECTOR(S)	ING-INF/02
HEAD PROFESSOR(S)	CINO ALFONSO CARMELO Ricercatore Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
YEAR	3
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**CINO ALFONSO CARMELO** Thursday 11:30 13:30 Ufficio del Docente (Edificio 9, DEIM, stanza U304)

DOCENTE: Prof. ALFONSO CARMELO CINO

TEACHING METHODS	Traditional lectures, Exercise classes, Calculations and computer Simulations.
ASSESSMENT METHODS	Written Exam + Oral Exam The 1-hour written exam, will consist of two parts: 1) first part deals with the analysis of a linear electric circuit which also presents transmission lines; 2) second part asks for a design, where the circuit analyzed at start has to be modified in order to compare some performance parameters. Evaluation mark is awarded on a 30-point scale and contributes to the final mark with a weight of about one third. Correct execution of at least first part is required for admission to oral exam, with a mark in the range 18-24. Correct execution also of second part regarding design, will bring the mark in the range 25-30. Evaluation considers both the appropriateness of methods and the correctness of numerical results. Oral exam begins with a discussion on the written exam, then proceeds with a series of questions which are meant to assess whether the student has acquired the skills and subject knowledge expected from the course; evaluation mark is awarded on a 30-point scale and contributes to the final mark with a weight of about two thirds. Questions are intended to verify a) the acquired knowledge on electromagnetic models and their limitations; b) the ability to apply models in technical applications scenarios; c) the possession of effective communication skills. In more detail, a) Regarding the verification of knowledge, it is required the ability to establish connections between the different course elements (physical theories, mathematical models, calculation and design tools, etc.). Minimal marks will be given when ability is mainly restricted to calculation and design aspects; higher marks when it combines also the physico-mathematical facets. b) Regarding the verification of the ability to apply models, it will be considered the capacity to account for, to take a critical look at and to modify, the choices made for the written exam. Minimal marks will be given when ability is mainly restricted to clarification of single points of the analysis/design; higher marks when it encompasses the skill to find new and proper design solutions after a change in the system under study. c) Regarding the verification of the communication skills, minimal marks will be given when the student uses a proper technico-scientific language but only at a basic level; higher marks when he is clear and articulate with the specific technical context of engineering electromagnetics.
LEARNING OUTCOMES	Knowledge and understanding On completion of this course the student will gain knowledge on the theory of electromagnetic waves, which should be considered both as the reference class of phenomena, and as an analysis/representation tool for engineering problems. In particular, the student will be able to understand, the consequences which originate from Maxwell's equations both in local and in integral forms. These equations will be applied to the study of transmission lines, of free plane waves propagation and of guided-wave propagation in metallic structures. To meet this objective, the course includes: Verification of this objective is based on a discussion of a few (mainly theoretical) course topics during the oral exam. Applying knowledge and understanding Students will be able to make use of calculus tools and software to construct simplified models in order to represent and quantify problems/applications where electromagnetic waves play a major role, in the first place the case of electrical circuits with transmission lines and waveguides. To meet this objective, the course includes: exercise classes on modelling and comparison between circuit and electromagnetic approaches; exercise classes on design problems. Verification of this objective is based on the design part of the written exam. Making judgments Students will be able to understand differences and similarities between the lumped-element circuit approach customary of circuit theory courses and the approach based on field and waves in specific sectors of electronics. In particular, they will be able to single out most suitable models to represent the functional blocks of a complex system (e.g., generator - transmission line - antenna). To meet this objective, the course includes: systematic comparison of circuit and electromagnetic points of view. Verification of this objective is pursued through the oral exam. Communication skills The students will develop the ability to describe and discuss physico-mathematical models useful to analyze applications based on the propagation of electromagnetic waves, in particular on spotting correctly relevant physical quantities and making use of specific terminology. To meet this objective, the course includes: group exercise classes and discussion of design software. Verification of this objective is based both on the written exam and on discussions during the oral exam.

	Learning skills The students will become aware of the variety of points of view connected with the ideas of circuit and circuit model, useful for the design phase. This will will expand the scope of techniques apparently already well-established during previous courses, into the perspective of wave propagation. This will help them to proceed with engineering studies on better, more mature, grounds. To meet this objective, the course includes: traditional lectures; analysis and discussion of design and multidisciplinary topics. Verification of this objective is based on discussions of specific course topics during the oral exam.
EDUCATIONAL OBJECTIVES	The electromagnetic fields course is aimed to give the fundamental knowledge concerning applied (engineering) electromagnetics, thus it considers as the core of the proposed educational experience –both as the reference class of phenomena, and as an analysis/representation tool– the theory of the electromagnetic waves. Basic concepts of electrostatics and magnetostatics, assumed as a background from physics course, will be revised and developed in order to allow a more precise presentation, also in an historical perspective, of Maxwell's equations in integral and local forms. Electromagnetic theory will be subsequently applied to the study of transmission lines, free plane waves propagation and guided-wave propagation in metallic structures. From a design point of view, it will be carried out a systematic comparison between the electrical circuit and the electromagnetic approaches, in order to point out similarities, peculiarities and limits.
PREREQUISITES	Electrostatics and magnetostatics. Electrical circuits analysis methods, in particular phasor approach/Steinmetz procedure. Fourier series.
SUGGESTED BIBLIOGRAPHY	Essenziali: 1) Maurizio Zoboli, Lezioni di campi elettromagnetici. Pitagora Editrice Bologna (2005), oppure la successiva edizione, Campi e onde elettromagnetici. Societa' editrice Esculapio (2011) 2) Luca Vincetti, Esercizi di campi elettromagnetici. Pitagora Editrice Bologna (2005) Per consultazione/approfondimenti: Fawwaz T. Ulaby: Fondamenti di campi elettromagnetici. McGraw-Hill, (2006) Giuseppe Conciauro, Fondamenti di onde elettromagnetiche. McGraw-Hill (2003) Dispense e SW libero reperibili in Internet (su indicazione del docente)

SYLLABUS

Hrs	Frontal teaching
4	Comparison "Classical electrodynamics" vs "Electromagnetic fields". the field concept, differential operators and coordinate systems.
2	Integral theorems and decomposition for vector fields. Advanced or computational issues.
2	Generalized Maxwell equations. Boundary conditions. Complex vectors.
2	Polarization of the electromagnetic field.
2	Constitutive relations for material media.
2	Wave equation and solution methods for vacuum and material media.
2	Stationary wave. Poynting's theorem. General EM field theorems. Sommerfeld radiation condition. Dispersion relation.
4	Waveguides and transmission lines. Classification, Maxwell equations for transverse and longitudinal field components. Classification of guided modes.
4	Telegrapher's equations. Lossy transmission lines. Telephone equation. Lumped element circuit models.
4	Traansmission line parameters in time-harmonic regime. Smith chart.
2	Waveguides, eigenvalues, modal expansion, dispersion. Metallic waveguides.
2	Plane waves and specific mathematical methods. Uniform and evanescent plane waves. Snell's law. Fresnel equations.
4	Interaction of electromagnetic waves with biological tissues.

Hrs	Practice
20	Exercise classes devoted to the application in practical cases of the general methods illustrated during lectures. In particular: a) Vector calculus; b) Differential operators in Cartesian, cylindrical and spherical coordinates; c) Calculations with representative complex vectors; d) Solution of the 1-dimensional D'Alembert equation; e) Polarization states and their representations; f) Characteristic parameters of dielectrics and conductors; g) Poynting's vector calculation for some cases of practical interest; h) In-depth study and usage of the Smith chart (transformations, matching, ...) both with traditional paper approach and computer-aided; i) Calculations of interaction parameters with biological tissues. For the analysis/design classes on transmission lines and circuits containing transmission lines, both general purpose and dedicated SW will be used. In particular, the following programs, freely available for academic use, will be considered: GeoGebra; TRLINE, TLDetails, TXLine, WAVES.