UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2021/2022
MASTER'S DEGREE (MSC)	ELECTRONICS ENGINEERING
SUBJECT	ELECTROMAGNETIC FIELDS
TYPE OF EDUCATIONAL ACTIVITY	D
AMBIT	20582-A scelta dello studente
CODE	01751
SCIENTIFIC SECTOR(S)	ING-INF/02
HEAD PROFESSOR(S)	CINO ALFONSO CARMELO Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	ELECTROMAGNETIC FIELDS - Corso: ELECTRONICS ENGINEERING ELECTROMAGNETIC FIELDS - Corso: INGEGNERIA ELETTRONICA
YEAR	2
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 (Ed. 9, III Piano) o canale del corso "Campi Elettromagnetici" su Teams

DOCENTE: Prof. ALFONSO CARMELO CINO

PREREQUISITES	Electrostatics and magnetostatics. Electrical circuits analysis methods, in particular phasor approach/Steinmetz procedure. Fourier series and transforms.
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, also in an historical perspective, 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 (with notes on dielectric counterparts). To meet this objective, the course includes: traditional lectures; analysis and discussion of specific technical applications. 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 and telecommunications. 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.
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. Reference scale for Grades EXCELLENT (30 - 30 and laude): Full knowledge and understanding of concepts and methods of the discipline, excellent analytical skills even in solving original problems; excellent communication and learning skills. VERY GOOD (27 - 29): Very good knowledge and understanding of concepts and methods of the discipline; very good communication skills; very good capability of concepts and methods applications. GOOD (24 - 26): Good knowledge of main concepts and methods of the discipline; discrete communication skills; limited autonomy for applying concepts and methods for solving original problems. SATISFYING: (21 - 23): Partial knowledge of main concepts and methods of the discipline; satisfying communication skills; scarce judgment autonomy. ACCEPTABLE (18 - 20): Minimal knowledge of concepts and methods of the discipline; minimal communication skills; very poor or null judgement autonomy. NON ACCEPTABLE (0 - 17): Insufficient knowledge and understanding of concepts and methods of the discipline.
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 (with notes on dielectric counterparts). 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.
TEACHING METHODS	Traditional lectures, Exercise classes, Calculations and computer Simulations.
SUGGESTED BIBLIOGRAPHY	TESTI CONSIGLIATI Principali: 1) Maurizio Zoboli, Lezioni di campi elettromagnetici. Pitagora Editrice Bologna (2005) ISBN: 8837115369, oppure la successiva edizione, Campi e onde elettromagnetici. Societa' editrice Esculapio (2011) ISBN: 8874884303 (quest'ultimo disponibile come e-book presso UniPa Discovery Service); 2) Luca Vincetti, Esercizi di campi elettromagnetici. Pitagora Editrice Bologna (2005) ISBN: 8837115393; 3) Michele Midrio, Esercizi di campi elettromagnetici. Edizioni Libreriauniversitaria.it (2022) ISBN: 9788833594453; 4) Sophocles J. Orfanidis, Electromagnetic Waves and Antennas, libro gratuito in inglese disponibile su www.ece.rutgers.edu/~orfanidi/ewa/. Per consultazione/approfondimenti (reference books): Fawwaz T. Ulaby, Umberto Ravaioli: Fundamentals of Applied Electromagnetics, Global Edition, Pearson (2015) ISBN: 1292082445; [vanno bene anche le traduzioni italiane dello stesso testo, come Fawwaz T. Ulaby, Fondamenti di campi elettromagnetici, McGraw-Hill, (2006), ISBN: 8838662657; oppure Fawwaz T. Ulaby, Umberto Ravaioli, Fondamenti di campi elettromagnetici, Pearson (2021) ISBN: 8891906611]; Giuseppe Conciauro - Luca Perregrini, Fondamenti di onde elettromagnetiche. Medea (2015), ISBN: 8866930741; Simon Ramo - John R. Whinnery - Theodore Van Duzer, Campi e onde nell'elettronica per le comunicazioni. Franco Angeli (2006), ISBN: 8820473852; Michael B. Steer, Microwave and RF Design, Vol. 2 Transmission

	Lines. NC State University (2019), ISBN: 9781469656939, e-book gratuito disponibile su https://repository.lib.ncsu.edu/handle/1840.20/36776; Altre dispense e SW libero reperibili in Internet (su indicazione del docente).

SYLLABUS

Hrs	Frontal teaching
4	Comparison "Classical electrodynamics" vs "Electromagnetic fields". Historical notes, the field concept, differential operators and coordinate systems.
4	Integral theorems and decomposition for vector fields. Advanced or computational issues.
4	Generalized Maxwell equations. Boundary conditions. Transforms and complex vectors.
4	Polarization of the electromagnetic field. Maxwell's equation in the wavenumber domain and the plane waves.
4	Constitutive relations for material media. Nonlinearity, anisotropy, stationarity, causality. Constitutive relations in the frequency domain. Analytical complements on vector fields representation.
4	Wave equation and solution methods for vacuum and material media.
4	Stationary wave. Poynting's theorem. Existence and uniqueness of solutions to Maxwell’s equations. General EM field theorems. Sommerfeld radiation condition. Dispersion relation.
6	Waveguides and transmission lines. Classification, Maxwell equations for transverse and longitudinal field components. Classification of guided modes.
6	Telegrapher's equations. Lossy transmission lines. Telephone equation. Lumped element circuit models.
4	Transmission line parameters in time-harmonic regime. Moebius transformation and the Smith chart.
4	Waveguides, eigenvalues, modal expansion, dispersion. Metallic waveguides.
4	Plane waves and specific mathematical methods. Uniform and evanescent plane waves. Snell's law and mention to Fresnel equations.
3	Introduction to electrodynamic potentials and radiation field.

Hrs	Practice
26	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) Detailed analysis of the metallic indefinite planar transmission line and of the metallic rectangular and circular waveguides. 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, AppCAD, SimSmith.