UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Fisica II - Turno 2

2021-2-E3001Q042-2

Aims

Classical electrodynamics and optics: phenomenology, fundamental laws and problem solving

Contents

Electrostatics in vacuum, Stationary electric current, Magnetostatics in vacuum, Electromagnetic induction, Electrostatics in materials, Magnetostatics in materials, Electromagnetic waves and fields, Optics.

Detailed program

1st Semester: Electricity and magnetism - (quasi-stationary limit)

1.1 - Coulomb's law and the principle of superposition, the potential energy of a charge configuration, the electric field and the field of a charge distribution, electric field (EF) flow, Gauss's law, examples of EF calculation for symmetric distributions, the electrical force on planar distribution, the energy associated with the EC

U2 - The electric potential, the relationship between the potential and the EF: the gradient, potential of a charge distribution, dipoles and multi-pole. The divergence of a vector, Gauss's theorem, the divergence of a vector and vector operators, differential form of Gauss's law; Laplace and Poisson equation; The rotor and the Stokes theorem, the meaning of divergence and rotor

U3 - Conductors and insulators, conductors in the EF, the general problem of the electrostatics: uniqueness theorems and boundary conditions, a way to solve the Laplace equation: the method of the image charges. Harmonic solutions (maybe). Capacitance and capacitors, induction coefficients, the energy stored in a capacitor

U4 - Electrical currents, current intensity and density, stationary currents and charge conservation, conductivity and Ohm's law, conductor properties, electrical circuits and circuit elements, energy dissipation (Joule's law), electromotive force, direct current networks and variable with resistors and capacitors

U5 - Field generated by moving charges: the magnetic force, invariance of the charge in motion, EF in different SRI, the field of a charge in uniform rectilinear motion, field of a charge that moves and stops, forces on a charge in motion, interactions between charges in motion; motion of charges in static magnetic fields.

U6 - **a)** The magnetic field: definition of the magnetic field and various relations (Lorentz, Laplace formulas, etc.), properties of the magnetic field: Ampere's law, magnetic flux, the vector potential, field of a wire traveled by current, examples of magnetic fields (rings and coils). **b)** Relativistic transformations of fields.

U7 - **a)** Magnetic induction: Faraday's observations, examples, the general formulation of the law of induction (Faraday-Neuman-Lenz), mutual and self-induction, the energy associated with the magnetic field. **b)**

U8 - The displacement current, Maxwell equations of the CEM, quasi-stationary limit. Some particular solutions (plane waves) for variable fields - non-stationary - in a vacuum, energy associated with a plane wave and Pointyng vector (introductory treatment).

U9 - Electrical fields in matter, dielectrics, multipoles, field and dipole potential, electrical polarization, Gauss theorem in dielectrics, properties of materials.

U10 - Magnetic fields in matter, Ampére's law in magnetized materials, Susceptibility and magnetic permittivity, Dia-, para- and ferromagnetic materials.

2nd Semester: Electrical and magnetic phenomena with variable fields; Optics

U12 - Electrodynamic potentials: quasi-stationary (delayed) and radiation fields; general method of solution with scalar and vector potential; equations for potentials; gauge invariance; the Coulomb and Lorentz gauge; wave equations for potentials; solution of the wave equation for a point source and generalization for an extended source; the retarded potential; oscillating dipole, potential and field; quasi-stationary term and radiation term.

U13 - Radiation by an accelerated charge; direct calculation of E, B, and ExB in the non-relativistic limit, irradiated power, Larmor relation. Synchrotron radiation and relativistic correction. Radiation of localized oscillating sources, multipole terms, the electric dipole; power emitted by an oscillating charge, radiation and damping, linear antenna (electric dipole), circular antenna (magnetic dipole).

U14 - Interaction of EM waves with media: a) Dielectrics: Oscillator model, absorbed and radiated power, Rayleigh diffusion and law, dynamic polarizability, complex refractive index; propagation of waves in a medium, normal dispersion and anomalous dispersion; resonant absorption; representation of a wave packet; phase speed and group speed; wave attenuation. b) Conductors: Maxwell equations in a conductor, wave equation in conductors, Helmoltz equation and complex refractive index; quality of the conductor according to frequency and conductivity; depth of skin; Reflection and transmission by normal incidence between dielectrics and dielectrics and conductors.

U15 - **Optics: a)** Geometric optics laws; conditions of continuity of the fields and relationship with the wave number vector; Fresnel relations for generic incidence and polarization in the incidence plane (other polarization by exercise); Brewster angle and reflection by polarization.

b) Interference: conditions of interference; interference with two sources; wavefront and amplitude separators. Multiple interference and interference pattern.

c) Diffraction: Huygens principle and diffraction integral; diffraction figures.

Prerequisites

First-year physics and math courses.

Teaching form

lectures (10 credits), classes (4 credits)

In the event of an extension of the pandemic restrictions, the lessons are held in a mixed-mode: partial attendance and recorded lessons with synchronous videoconferencing, if technically possible.

Textbook and teaching resource

- E.M Purcell and D.J. Morin, Electricity and Magnetism, 3rd Edition, Cambridge (Amazon) - U1-10
- S. Focardi, I. Massa, A. Uguzzoni, Onde e ottica, CEA - U12-16.

Some of the topics covered in units U11-U15 are described in accordance with:

- R. Feynman, The Feynman Lectures on Physics, Vol II - Online: http://www.feynmanlectures.caltech.edu/

Additional textbooks that may be used or suggested for further reading on selected topics include:

- D.J. Griffiths, Introduction to electrodynamics, Cambridge (Rather comprehensive)
- J. Jackson, Classical Electrodynamics, Zanichelli (Advanced)
- Mencuccini e Silvestrini, Elettromagnetismo e Ottica, Ed. Ambrosiana - U1-14
- Mazzoldi-Nigro-Voci, “Fisica Generale (vol.2)”, Edises

Semester

1st and 2nd semesters

Assessment method

Two mid-term written tests (or final tests in case the mid-term tests were failed) and an oral interview at the end of the course.

Office hours

Upon request