UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Fisica II

2122-2-E2701Q060

Aims

The course gives the fundamentals of electromagnetism and optics as a tool for the understanding of the interactions between materials and electromagnetic fields, including light.

At the end of the course, students know how to approach the analysis of phenomena and systems involving interactions between electric charges according to a classical approach and are able to use the basic mathematical tools for their quantitative description.

Contents

The course starts from the description of the interactions between charged systems and introduces the concepts of electric field, flux of electric field, electrostatic energy and potential, giving the formal elements for both an integral and differential description. The course gives then the basis for the description of charging processes in conductors and polarization effects in dielectrics with the fundamental quantities describing charge transport in the electric conduction processes. The analysis of moving charges brings to the introduction of the concept of magnetic field and the interaction between magnetic fields and moving charges, including charged systems with magnetic dipole moment. The course then analyses the electric and magnetic contributions arising from time dependent fields, finally giving the general framework of Maxwell equations in their integral and differential forms. From these equations, the wave equations for the electric and magnetic components of the electromagnetic radiation are obtained, with also the basis for the general analysis of optical signals as overlapping monochromatic components. Finally, the course gives a short analysis of the formal tools for the description of both geometrical optics and electromagnetic wave propagation.

Detailed program

Electric charge. Conductors and insulators. Electrostatic induction. Description of electrostatic interactions in terms of the force between electric charges. Coulomb's law. Dielectric constant of vacuum. Principle of superposition. The concept of field. Force fields in physics. The electrostatic field generated by point charges. Description of continuous charge distributions and examples of electric fields. Motion of a charge in an electrostatic field: energy conservation.

Electric force and work. Work and potential energy. Conservative fields. Potential energy and electrostatic potential. Potential generated by point charges and continuous charge distributions. Relations between field and potential. Electric dipole. Dipole field and potential. Dipole in an external field.

Flow of a vector field. Flux of the electrostatic field. Gauss's law. Applications of Gauss's law. Insulated charged conductor. Electrostatic induction. Electrostatic screen. Capacity of a conductor. Capacitors. Calculation of the capacitance of a capacitor. Capacitors in series and in parallel. Energy and energy density of the electric field. Capacitors with dielectrics. Relative dielectric constant. Polarization of dielectrics.

Electric current. Current intensity and density. Resistivity and conductivity. Ohm's law in local form. Microscopic model of electrical conduction. Resistors in series and parallel. Joule effect. Electromotive force generators. Kirchhoff's laws.

Magnetic interaction and magnetic field. Moving charges in magnetic field. Laplace's second law. Electric currents in magnetic field. Mechanical moments on plane circuits. Magnetic dipole moment. Hall effect. Motion of charged particles in a magnetic field. Magnetic field generated by electric currents and moving charges. Laplace's First Law. Magnetic field generated by an infinite straight wire. Ampère's law. Applications of Ampère's law. Magnetic interaction between currents. Magnetic field generated by a circular coil and a solenoid. Local form of Ampère's law. Displacement current. Ampère-Maxwell equation. Magnetic materials. Magnetization. Dia, para and ferromagnetism.

Faraday's law; induced electromotive force and its origin. Induced electric fields. Applications of Faraday's law. Inductance. Energy and energy density of the magnetic field. Properties of induced electric fields and magnetic fields.

Maxwell's equations. Continuity equation of current. Maxwell's equations for time-varying fields in integral and differential form. Induced electric and magnetic fields. D'Alambert's equation for electromagnetic waves. Plane waves. Poynting vector. Intensity of plane waves. Polarization of waves: linear, circular and elliptical polarization. Notes on Fourier's analysis of waves and pulses.

Fundamentals of wave optics. Spherical waves. Speed ??of light in vacuum and in transparent media. Refraction and dispersion index. Huygens-Fresnel principle. Reflection and refraction. Spherical wave propagation, reflection and refraction and the role of material polarization.

Principles of geometric optics. Concave and convex spherical mirrors. Flat mirrors. Thin lenses. Interference between electromagnetic waves. Basic principles for the interpretation of interference phenomena.

Prerequisites

Basic knowledge of Mathematical analysis and Newtonian physics.

Teaching form

The course comprises lectures including practical exercises and summary lessons on the main three lecture blocks on i) electrostatic, ii) electric currents and magnetism, and iii) time dependent effects and optics, respectively.

Interactive and group works are also planned, concerning the quantitative analysis of electromagnetic interactions on case studies related to materials and devices.

Textbook and teaching resource

Reference textbook:

Elementi di fisica, Elettromagnetismo e onde – P. Mazzoldi, M. Nigro, C. Voci – EdiSES 2008

Additional resources:

Exercises with resolution on the e-learning platform.

Semester

First semester

Assessment method

Students must first demonstrate in a written test – usually composed by one to three exercises – to possess the formal tools for the description and quantification of situations in which charged systems and/or moving charges interact with each other and with either static or time dependent electromagnetic fields, and for the description of electromagnetic waves and simple optical systems.

After the written test, the exam includes an interview aimed at assessing the level of knowledge acquired on the entire program and verifying the awareness achieved of the physical meaning of electromagnetic quantities and relationships.

Office hours

11:00-13:00 Monday, Thursday, Friday

14:00-17:00 Thursday