GENERAL PHYSICS II

12 CFU - 1° and 2° Semester

Teaching Staff

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LEARNING OBJECTIVES

- **Module I**
  The main aim of the course is to provide a basic knowledge of classical electromagnetism topics listed in the program as well as to teach pupils how to apply the Scientific Method to real problems.

- **Electromagnetism**
  The course aims at providing the student with a somewhat detailed understanding of the electromagnetic field, its interaction with matter, as well as physical and geometrical optics.

  Knowledge and understanding:

  Knowledge of the basic phenomenology of electromagnetism and (very basic) structure of matter, as well as the interaction between (electromagnetic) radiation and matter. Understanding of their physical implications and their mathematical description.

  Applying knowledge and understanding:

  Ability to identify the main physical laws underlying an electromagnetic phenomenon, and to apply them to solve problems and exercises at a various level of complexity and approximation (both physical and numerical), using both analytical and numerical techniques, as appropriate.

Making judgements:

Estimating the order of magnitude of the main variables intervening in electromagnetism. Assessing the level of importance of a physical law (axiom, conservation law, universal law, theorem, global/integral vs local/differential version of a given law, and its degree of generality, properties of the materials, etc)

Communication skills:

Ability to describe scientific concepts with property of language, at various levels.

Learning skills:

Application of concepts and mathematical-theoretical techniques to physics.

DETAILED COURSE CONTENT

- **Electromagnetism**
  Maxwell equations. Their derivation from the laws of electromagnetism. Scalar and vector potentials. Gauge invariance. Lorentz gauge. Coulomb gauge. Helmholtz theorem. Energy and momentum density of the electromagnetic field. Poyinting theorem and its vector. Maxwell tensor. Radiation pressure. Perfectly absorbing and perfectly reflecting surface.

  Waves. D'Alembert equation. Its general integral and initial values problem. Superposition principle for linear PDEs. Derivation of the wave equation for elastic waves in a solid rod and in a tight rope. Longitudinal and transverse waves. Harmonic plane waves. Wave frequency and wave vector. Wave period and wavelength. Dispersion relation. Phase. Fourier series. Linear, elliptic, circular polarization. Wave intensity. Energy propagation in wave phenomena. Three-dimensional waves. Wave front. Wave radius. Spherical waves. Laplacian in polar coordinates. Wave packet. Phase and group velocities. Doppler effect.

  Electromagnetic waves. Hertz experiment. Plane waves. Polarization and helicity of an electromagnetic wave. Huygens-Fresnel principle and Kirchhoff theorem (hints). Reflection and refraction of an electromagnetic wave. Laws of Snell-Descartes. Reminder: refraction of the lines of the electromagnetic field. Fresnel formulas for waves polarized in a perpendicular and in a parallel direction to the incidence plane. Reflected and refracted intensity. Limit angle. Wave guides. Optical fibers. Brewster angle. Polaroids. Malus experiment. Dispersion and absorption. Mechanical analogy. Reminder: elliptic polarization.

  Electromagnetic waves in matter. Drude-Lorentz model. Constitutive relations: phase difference between P and E. Physical meaning of the imaginary part of the dielectric function $\varepsilon(\omega)$. Qualitative behaviour of $\varepsilon(\omega)$ within the Drude-Lorentz model. Group velocity in a dispersive mean. Static and high-frequency limits: (dielectric) insulators and metals. Plasmas and their oscillations.

Interference. Superposition principle. Coherent sources. Optical path. Young double-slit experiment. Fresnel mirrors. Interference among N sources. Thin films. Thin wedge. Newton rings. Michelson interferometre.

Diffraction. Fresnel and Fraunhofer formulation. Fresnel diffraction by an obstacle. Fraunhofer diffraction by a rectangular slit. Analogy with Fourier transforms. Fraunhofer diffraction by a circular slit. Bessel functions (hint). Resolutive power of an optical system: Rayleigh criterion. Diffraction lattice. Dispersion. Emission and absorption spectra (hints). X-ray diffraction by crystals and quasicrystals (hints).

Geometrical optics. Eikonal equation and its physical meaning. Ray equation. Optical path. Reflection and refraction laws (again). Lagrange integral invariant. Fermat principle. Laws od Snell and Descartes. Main optical systems: plane and spherical mirrors; prism; spherical and plane dioptre; thin and thick lenses.

TEXTBOOK INFORMATION

- **Module I**
  1. R. P. Feynman, R. B. Leighton e M. Sands, *La Fisica di Feynman – Vol. 1 e 2* (Zanichelli, Bologna, 2007) - this book is also in English;
  2. P. Mazzoldi, M. Nigro e C. Voci, *Fisica - Volume II - II Edizione* (EdiSES, Napoli, 2008).
- **Electromagnetism**
  Textbooks recommended for Modulo 1:
  - Si veda la pagina: http://studium.unict.it/dokeos/2016/main/course_description.

  Textbooks recommended for Modulo 2:
  1. J. D. Jackson, Classical Electrodynamics (J. Wiley & Sons, Hoboken, NJ, 1998).
  2. P. Mazzoldi, M. Nigro, and C. Voci, Fisica. Vol. 2: Elettromagnetismo, Onde, 2 ed. (EdiSES, Napoli, 2007).
  3. L. D. Landau and E. M. Lifsits, Teoria dei campi (Ed. Riuniti – Ed. Mir, Roma – Mosca, 1985); *also available in English.*
  4. M. Born and E. Wolf, Principles of Optics (Pergamon, Oxford, 1980).
  5. H. D. Young, R. A. Freedman, A. Lewis Ford, Principi di fisica. Vol. 2: Elettromagnetismo e ottica (Pearson, Milano, 2016); *also available in English.*
