UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physics II

2425-2-E2702Q004

Aims

The course aims to teach the fundamentals of electromagnetism and wave optics.

- Knowledge and understanding abilities: Knowledge of the main electrical, magnetic, and wave optical phenomena, and an understanding of the mathematical models that describe them.
- Applied knowledge and understanding: Knowledge of the main experimental applications of the laws of electromagnetism and the ability to understand the operation of simple devices based on electromagnetism.
- Judgment autonomy: The ability to independently assess whether a natural or laboratory phenomenon can be described by the laws of electromagnetism.
- Communication skills: The ability to clearly describe the laws of electromagnetism and their applications.
- Learning ability: The ability to learn the laws of electromagnetism at a level appropriate for solving simple quantitative problems.

Contents

Electric field and potential, Coulomb law, Gauss theorem. Electrical currents and some simple circuits. Magnetic field, Lorentz force, Biot-Savart and Ampere laws. Magnetic induction, Faraday and Lenz laws. Maxwell equations and electromagnetic waves. Poynting vector and energy. Elements of geometrical optics and fundamentals of wave optics: Huygens principle, interference and diffraction.

Detailed program

Part one: vacuum electrostatic, electrical currents and vacuum magnetostatic

- Electric fields
Experimental aspects of the electrical interactions. Coulomb's law. Electric field: definition, superposition principle and results for point charges. Electric field by a generic charge distribution. Electric field lines. Motion of a charge in a uniform electric field.

- Gauss's law
Electric flux, Gauss's theorem and applications. Properties of the electric field in a conductor at equilibrium.

- Electric potential
Electric potential and potential difference. Potential difference for a uniform electric field and for the eletric field due to point charges. Relation between electric field and eletric potential. Potential due to continuous charge distributions. Properties of the electric potential in conductors and applications.

- Capacitance, capacitors and dieletrics
Definition and calculation of the capacitance of a conductor and of a capacitor. Series and parallel connection of two capacitors. Energy stored in a capacitor. Brief description of the properties of capacitors filled by dielectric materials.

- Electrical current and applications
Definition of electrical current and its microscopic interpretation. Resistance, resistivity and Ohm's law. Brief description of the properties of the resistance as a function of temperature. Electric power. Series and parallel connection of two resistors. Properties of capacitors in an RC circuit.

- Magnetic fields
Experimental aspects of magnetic interactions. Force on a moving charge in a magnetic field. Motion of a charge in a uniform magnetic field and applications. Force acting on a infinite current carrying wire. Magnetic moment and mechanical moment acting on a coil. Principle of operation of the electric engine. Hall effect and magnetic field measurements.

- Sources of magnetic field
Oersted's experiment and Biot-Savart's law. Properties of the magnetic field produced by an infinite current carrying wire and by a circular coil. Magnetic force between two nearby current carrying wires and practical definition of Ampere. Ampere's law and its application to an infinite current carrying wire, a toroid and an infinite solenoid. Gauss's theorem for the magnetic field.

Part two: electromagnetism, optics and elements of modern physics

- Faraday's law
Faraday's induction law and e.m.f. on a moving circuit. Lenz's law and induced electric fields. Electric generators and engines.

- Induction

Self induction and self induction coefficient. RL circuits. Energy stored in a magnetic field.

- Electromagnetic waves
Displacement current and Maxwell's equations. Plane electromagnetic waves, energy and momentum carried by an electromagnetic wave. Electromagnetic spectrum.

- Nature of light and laws of ray optics
Main properties of light and ray optics. Huygens' principle.

- Wave optics

Interference between two light waves and Young's experiment. Phase shift from wave reflection and interference

from thin films. Michelson's interferometer and some applications.

- *Diffraction*
Diffraction from thin slits. Limitation to the resolution of optical instruments due to diffraction. Diffraction grating and diffraction from crystals. Elements of light polarization.

Prerequisites

Content of the physics and mathematics courses taught during the first academic year

Teaching form

Frontal lessons on theory and problem solving. Lectures will be in Italian and will include:
• 21 in-person lectures on theory (2 hours each; 42 hours in total)
• 12 in-person lectures on problem solving (2 hours each; 24 hours in total)

Textbook and teaching resource

Textbooks:

- Serway, Jewett, "Fisica per Scienze ed Ingegneria", vol. 2, ed. EdiSES (also available in English)

Further study material:

- Solved written exams published on the e-learning page of this course

- Solutions to the problems found in the textbook Serway, Jewett, "Fisica per Scienze ed Ingegneria", vol. 2, ed. EdiSES (also available in English) as provided by the Editor.

Semester

First semester

Assessment method

Exam Procedures

The exam consists of a written test and, if necessary or requested by the student, a final oral test. To participate in the written test, students must register via the link provided on the course webpage. To take the oral test or to have the exam grade recorded, students must register for a session through the Online Secretariat.

Each submitted written test remains valid for eight exam sessions, starting from the one following the test date. The written test is graded on a scale of up to 32 points. To qualify for the oral exam, students must obtain a minimum score of 15. Students who score at least 20 on the written test have the option to forgo the oral exam. In this case, they must send an email to the professor accepting their grade and specify the session they are registered for, so that the result can be officially recorded through the Segreterie Online. The final exam grade, in this case, will be the score obtained in the written test, rounded up to the nearest whole number. If the score exceeds 30, the student is awarded a grade of "30 with honors."

The oral test is mandatory for students who score between 15 and 19 on the written test. It can be taken in the same session as the last written test or in a later session.

Structure of the Written Test

The written test covers only the topics discussed during lectures and exercise sessions, as outlined in the detailed syllabus available on the course webpage. During the test, students are allowed to use a pocket calculator (or equivalent tool) and a printed copy of the course formula sheet (available on the course webpage). The use of personal notes or textbooks in any form is not permitted.

Students taking the written test must present their university ID for identification. The written test consists of four open-ended questions, both theoretical and applied (including problem-solving), with a total duration of 120 minutes.

Structure of the Oral Test

The oral test primarily aims to address any deficiencies identified in the written test. It consists of a maximum of two questions, both theoretical and applied, covering the topics that were most uncertain based on the written test results. Each question is graded on a scale of 0 to 8, and this score replaces the corresponding score from the written test.

The final exam grade is the sum of the scores from the written and oral tests. If the total score is at least 18, the student passes the exam, and the final grade is the total score rounded up to the nearest whole number. If the score exceeds 30, the student is awarded "30 e lode." If the total score is below 18, the student fails the exam and must retake the written test as well.

Midterm Tests

To facilitate the successful completion of the exam, students have the option to replace the written test with two midterm exams, taken on two different dates set during the course (typically in November and January) during lecture or exercise hours. On these dates, lectures are suspended to allow students to take the midterms.

Each midterm consists of three open-ended questions, either theoretical or applied (problem-solving), and is graded on a scale of 0 to 16 points. The first midterm covers electrostatics, electric currents, and magnetostatics. The second midterm includes all remaining topics covered in lectures and exercises. The rules for the midterm exams are the same as those for the main written test. Participation in midterm exams is strongly encouraged.

Exams can be taken in either Italian or English, at the student's discretion.

Grading of evaluations

18-19: Preparation on a limited number of topics from the course syllabus, with limited ability to address and apply them to problem-solving. In the case of the oral exam, these abilities only emerge with the help and questions from the instructor. Presentation skills and vocabulary are not always correct, with limited critical thinking abilities.

20-23: Preparation on a portion of the topics in the course syllabus, with the ability to apply knowledge to solve only simpler problems. Correct vocabulary is used, although not entirely accurate or clear, and presentation skills are

occasionally uncertain.

24-27: Preparation on a wide range of topics covered in the course syllabus, with the ability to apply knowledge to solve problems of intermediate difficulty. Correct vocabulary is used, and there is competence in the use of disciplinary language.

28–30/30L: Complete and thorough preparation on the topics of the exam syllabus, with the ability to critically analyze topics and apply knowledge to solve even fairly complex problems. Full mastery of disciplinary vocabulary and rigorous, well-structured presentation skills.

Office hours

By appointment via email

Sustainable Development Goals

QUALITY EDUCATION | DECENT WORK AND ECONOMIC GROWTH