# General Physics II

## Prof. Gabriele Ferrini

***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

The course aim is an introduction to the basic notions of electrostatics in vacuum and in matter (dielectrics and conductors), of magnetostatics in vacuum and in matter (linear magnetic materials, ferromagnetic materials), of electromagnetic induction. At the end of the course, the student will be able to explain the physical meaning of Maxwell's equations and use them to solve electrostatic problems related to the charging of material bodies (dielectrics and conductors) and explain the action of currents in the stationary regime, including cases of linear magnetic materials.

***COURSE CONTENT***

Coulomb's law, principle of superposition, electric field. The electric field flux and Gauss' law. Conservative fields and the electric potential. Definition of volume, surface and line charge. Divergence, curl and fundamental theorems.

The fundamental equations of electrostatics: Poisson and Laplace. Electrostatic boundary conditions for fields and potentials. Symmetry operations on charge distributions and consequences for potentials and fields.

Conductors, induced charges, Coulomb's theorem. The method of images. Capacitance of conductors: capacitive and inductive coefficients. Capacitors. Energy of a conductor distribution. Volume energy associated to the electric field. Force on a conductor.

The electric dipole. Multipole expansion. The dipole moment. Force, torque and energy of a dipole in an electric field. Charge density due to polarization and electric field of a polarized object. The electric displacement and the constitutive equation for linear dielectrics. Gauss' law in the presence of dielectrics. Boundary value problems with linear dielectrics. Capacitors with dielectrics. Energy in dielectric systems.

Currents, battery, electromotive field. Continuity equation. Microscopic derivation of resistivity. Equations for steady currents, boundary conditions.

The magnetic effects of steady currents. The Grassman force law between circuits. The Lorentz force. The Biot-Savart law. The divergence and curl of the magnetic field and the vector potential. Ampere's law. Symmetry arguments connected to Ampere’s law. Vectors and pseudo-vectors. Magnetostatic boundary conditions.

The vector potential of a magnetic dipole. Torques, forces and energy of a magnetic dipole in a magnetic field. The auxiliary field H. Constitutive relations for linear magnetic materials. Bound currents and boundary conditions. Ferromagnetism and hysteresis loop. Comparison of electrostatics and magnetostatics.

Electromagnetic induction and Faraday's law. Experimental observations. Universal flux rule. Non conservative fields. What do voltmeters measure? (mutual- and self-) inductance. Energy in magnetic fields. Displacement current. Maxwell equations in free space and in matter. Existence of the electromagnetic waves.

References to the fundamental concepts of Modern Physics will be introduced in the course, with topics that fall within those provided for in the Framework of Reference for the II Physics test of the State Exam for Scientific High Schools. This is in favor of those who will not continue in their studies deepening aspects related to Quantum Mechanics and in general to the physics of the second half of the twentieth century.

***READING LIST***

D. J. Griffiths, *Introduction to electrodynamics*, Prentice Hall, 1999.
R. P. Feynman , R. B. Leighton, M. Sands, *The Feynman Lectures on Physics*, Addison Wesley, 2nd edition (26 Aug 2005).
S. Focardi, I. Massa, A. Uguzzoni*, Fisica Generale, elettromagnetismo*, Casa Editrice Ambrosiana, 2003 (in Italian).

***TEACHING METHOD***

Lectures and recitations.

***ASSESSMENT METHOD AND CRITERIA***

The examination consists in a written examination and an oral examination.

The written examination will consist of one or more problems in which the student must show that she/he can apply the concepts developed during the lectures to specific situations, similar or related to those shown in the recitations. The evaluation of the written test will take into account the correctness of the results and the quality of presentation. Passing the written examination is a necessary condition for the admission to the oral examination.

The oral examination aims to assess the degree of assimilation of the concepts illustrated in the lectures. The student should be able to understand spoken technical questions or problems from the examiners and to give responses, both in words and by writing equations and figures on the blackboard. The questions and/or problems will focus on selected topics of the program, not excluding references to prerequisites or connections between parts of the same. The evaluation of the oral examination will take into account the correctness of the students’ responses, their exposition quality and their ability in problem solving.

The final grade is unique and takes both examinations into account. The basis of the vote is the mark of the written test, out of thirty, which can be reduced or increased by the evaluation of the oral test. The maximum increase is usually limited to three points.

***NOTES AND PREREQUISITES***

The course of General Physics I is a prerequisite to the course of General Physics II. It is strongly recommended to follow the course of General Physics II after having learned the basic concepts of Mathematical Analysis (functions, integrals, derivatives).

Prof. Gabriele Ferrini receives the students after the lectures or by appointment.

*Further information can be found on the lecturer's webpage at http://docenti.unicatt.it/web/searchByName.do?language=ENG or on the Faculty notice board.*