General information	
Academic subject	**GENERAL PHYSICS II mod A**
Degree course	(L-30) Physics
Academic Year	2022-23
European Credit Transfer and Accumulation System (ECTS)	9
Language	Italian
Academic calendar (starting and ending date)	september-december (I semester) – II year
Attendance	no

Professor/ Lecturer	
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Department and address	Interuniversity Department of Physics
Virtual headquarters (Microsoft Teams code)	Teams Class: 0hrd50
Tutoring (time and day)	By appointment, to be fixed via email or phone call to the course professors

Syllabus	
Learning Objectives	The course aims at providing a basic knowledge of electromagnetism.
Course prerequisites	Understanding of a text, notions of geometry, algebra and elementary trigonometry. Differential and integral calculus of functions with one variable. Differential equations of the first and second order. Scalar and vector quantities. Newton's laws and motion equations. Kinetic and potential energy.
Contents	**1) Electrostatic force. Electrostatic field** Electric charges. Insulators and Conductors. Electrical structure of the matter. Electrostatic induction. Coulomb's law. Vector form of Coulomb's law. Electrostatic field. Electrostatic force in a system of three charges. Electrostatic field produced by a continuous distribution of charges. Lines of force of an electrostatic field. Electrostatic field of a charged wire. Electrostatic field of a charged ring. Electrostatic field of a charged disk. Electrostatic field of two charged indefinite fields. Motion of a charge in an electrostatic field. Rectilinear motion of a charge in an electrostatic field. Reasoned problem solving. **2) Electrical work. Electrostatic potential** Work of the electric force. Voltage, potential. Calculation of the electrostatic potential. Electrostatic potential energy. Electrostatic energy of three charges. Motion of a charge in an electrostatic field. Conservation of energy. Electrostatic field as the gradient of the electrostatic potential. Electrostatic field of a point charge derived from the potential. Potential of a charged thin wire, a charged ring, a charged disc. Electrostatic potential between two charged planes. Equipotential surfaces. Rotor of a vector field. Stokes theorem. Application to the electrostatic field. Electric dipole. Force on an electric dipole. Dipole in a non-uniform electric field. Reasoned problem solving. **3) Gauss' law** Flux of the electrostatic field. Gauss's law. Proof of the Gauss' law. Some applications and consequences of the Gauss' law. Electrostatic field produced by a spherical surface charge distribution, by a uniformly charged sphere, by an undefined charged cylinder, by a plane charge distribution. Electrostatic field around a surface layer of charge. Gauss' law in differential form. Divergence of a vector field. Solenoidal vector fields. Maxwell's equations for electrostatics. Poisson and Laplace equations. Reasoned problem solving. **4) Conductors. Electrostatic energy** Conductors in equilibrium. Capacity of an insulated conductor. Capacity of an insulated spherical conductor. Two conducting spheres connected by a thin wire. Hollow conductor. Electrostatic screen. Derivation of the Coulomb's law from the Gauss's law. Hollow conductors with electric charges inside. Two concentric

spherical conductors. conductor systems. capacitors. Capacity of a spherical capacitor. Capacity of a cylindrical capacitor. Capacity of a plane capacitor. Electrostatic field of the Earth's atmosphere. Connection of capacitors in series and in parallel. Electrostatic field energy. Electrostatic energy of a spherical capacitor. Electrostatic energy for two capacitors in parallel. Electrostatic potential energy of a system of charges. Electrostatic potential energy of two spherical conductors. Electrostatic energy of a charged sphere. Reasoned problem solving.

5) Dielectrics

Dielectric constant. Polarization of dielectrics. Electrostatic field produced by a polarized dielectric. Electrostatic field inside a polarized dielectric. General equations of electrostatics in the presence of dielectrics. Dielectric induction vector. Dependence of polarization on the electrostatic field. Electrostatic field of a conducting sphere inside a dielectric. Field discontinuity on the surface separating two dielectrics. Slab of a dielectric material inside an insulated planar capacitor. Two dielectric slabs inside a planar conductor. Dielectric strength. Electrostatic energy in dielectrics. Dielectric plate sandwiched partially between the plates of an insulated capacitor. Reasoned problem solving.

6) Electric current

Electrical conduction. Velocity of conduction electrons in a metal. Electric current. Current density and drift velocity. Law of conservation of charge. Steady current regime. Classical model of electrical conduction. Ohm's law. Ohm's law for metallic conductors. Electrical resistance. Joule effect. Thermal effects. Power. Joule effect. Superconducting materials. Resistors in series and in parallel. Resistors in series. Resistors in parallel. Electromotive force. Electromotive field of a generator. Van de Graaf generator. Charging and discharging a capacitor through a resistor. Charging a capacitor. Discharge of a capacitor. Kirchhoff's laws for electrical networks. Calculation of the resistance of three-dimensional conductors. Reasoned problem solving.

7) Magnetic field and magnetic force

First experimental facts about magnetic interactions; electricity and magnetism. Magnetic field lines. Gauss' law for the magnetic field; electrostatic field and magnetic field. Magnetic force on a moving charge: motion of a particle in a magnetic field, motion in a uniform magnetic field, $\theta=\pi/2$, motion in a uniform magnetic field, θ generic. Magnetic force on a current-carrying conductor. Mechanical moments of flat circuits. Ampère's equivalence principle. Force on a circular loop in a magnetic field. Expressions of force, momentum and work by magnetic flux. Hall effect. Examples of motions of charged particles in a uniform magnetic field. Mass spectrometers. Bainbridge speed selector and spectrometer. Cyclotron. Reasoned problem solving.

8) Sources of the magnetic field and Ampère's law

Magnetic field produced by a current, magnetic field produced by a moving charge. Magnetic fields produced by particular circuits: indefinite straight wire and Biot-Savart law, magnetic field produced by a square loop, circular loop, magnetic dipole-magnetic dipole mutual interaction, Rowland disk, rectilinear solenoid. Electrodynamic actions between current-carrying circuits. Principle of action and reaction for two current-carrying circuits. Ampere's law. Magnetic field of an undefined rectilinear conductor. Magnetic field of an undefined rectilinear solenoid. Magnetic field of a toroidal solenoid. Magnetic field of an indefinite plane current. Properties of the magnetostatic field in vacuum. Magnetic field discontinuity. Relativity of electric and magnetic fields. Reasoned problem solving.

9) Time-depending electric and magnetic fields

Introductory concepts: electromotive force of an electric field, magnetic field flux. Faraday's law of electromagnetic induction. Lenz's law. Physical origin of the

	induced electromotive force. Translational motion of a conductor in a magnetic field. Conductive circuit with a moving side in a magnetic field. Electric fields induced by temporal variations of a magnetic field. Electromotive force induced by temporal variations of a magnetic field. Applications of Faraday's law: electromagnetic friction, generators, sinusoidal current generator, electric motors, Foucault currents. Felici's law and measurements of the magnetic field, Palmieri's circle. Self-induction. Inductance of a toroid and a solenoid. Series RL circuits. Magnetic energy. Magnetic energy in a toroidal solenoid, in a coaxial cable. Mutual induction. Mutual induction between coaxial solenoids and between coupled circuits. Magnetic energy of coupled circuits. Magnetic energy of two coupled circuits. Mutual induction between two solenoids. Oscillations of a coil. Displacement current and Ampère-Maxwell's law. Displacement current in a planar capacitor. Maxwell's equations. Electromagnetic waves equation. Reasoned problem solving.
Books and bibliography	*P. Mazzoldi - N. Nigro - C.Voci - (Vol. 2) Elettromagnetismo e Onde, Terza edizione*
Additional materials	

Work schedule			
Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
93	48	45	132
ECTS			
9	6	3	

Teaching strategy	Lectures and exercises

Expected learning outcomes	
Knowledge and understanding on:	Goal of this course is providing students with the basic knowledge of electromagnetism (in static and dynamic conditions, in vacuum or in matter). At the end of the course the student will have acquired this knowledge and will be able to solve simple problems of electromagnetism. Understanding of how the laws of Physics are verified by famous examples and experiments.
Applying knowledge and understanding on:	Ability to set up and solve problems related to classical electromagnetism. Ability to identify the essential elements of a phenomenon, in terms of order of magnitude and level of approximation required.
Soft skills	**Making informed judgments and choices** Development of the critical sense necessary to discern the significant aspects from the marginal ones, to evaluate the correctness of the assumptions and approximations adopted. Development of analytical skills aimed at identifying inconsistencies and possible sources of error, including dimensional checks. Ability to recognize the variety and beauty of discoveries and electromagnetism. Ability to evaluate logical structure in the presentation (formal or informal, written or oral) of physics topics. This ability to self-assessment is required in the various tests that the student must pass. **Communicating knowledge and understanding** Acquisition of competence in communication in Italian, and of the rigor necessary for the topics covered

Assessment and feedback	
Methods of assessment	
Evaluation criteria	The final evaluation mark is decided by the Commission on the basis of the outcome of written and oral exams. The written test is passed if: • Both exemptions are passed (generally the first exemption is carried out during the courses break of the first semester, and the other immediately after the end of the course), or • The written test is passed in one of the foreseen examination sessions. The written test is considered passed when the student has achieved at least a sufficient evaluation mark. If the written test is passed, the oral test can be given in any session scheduled during the same exam session (summer or winter). If the oral test is not passed, then the written test again should be given again.
Criteria for assessment and attribution of the final mark	The written exam constitutes an access test to the oral exam and is intended to verify the student's ability to solve problems related to the topics covered during the course. In the oral test, the ability to illustrate the topics to other people, connect different parts of the program, use the scientific language introduced in the course and the mathematical formalism appropriately to the level of the course are evaluated.
Additional information	