UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

CONSIGLIO INTERCLASSE IN MATEMATICA

COURSE OF STUDY — TWO-YEAR MASTER OF SCIENCE PROGRAMME IN MATHEMATICS

ACADEMIC YEAR — 2024-2025

ACADEMIC SUBJECT — COMPLEMENTS OF GENERAL PHYSICS

General information	
Programme year	First
Term	Second semester (February 24, 2024 – May 30, 2024)
European Credit Transfer and Accumulation System credits (ECTS)	7
SSD	FIS/01
Language	Italian
Mode of attendance	Not mandatory, but strongly recommended

Lecturers		
Name and surname	Marcello Abbrescia (instructor of record)	Francesco Barile
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Department and office	Department of Physics, room R24	Department of Physics, room R46
Virtual meeting room	Microsoft Teams, code 85ck2l2	Microsoft Teams, code 85ck2l2
Web page	https://www.uniba.it/it/docenti/abbrescia-marcello	https://www.uniba.it/it/docenti/barile-francesco
Office hours	By appointment, to be fixed via email or phone call to the professor.	By appointment, to be fixed via email or phone call to the professor.

Work schedule	Total	Lectures	Hands-on learning (recitations/laboratories)	Self-study
Hours	175	40	16	119
ECTS credits	7	5	2	

Learning objectives	
	The course aims at providing knowledge of time-dependent electric and magnetic fields, electromagnetic waves, physical optics, and, moreover, on the basic concepts of special relativity and quantum mechanics.

Course prerequisites	
	Understanding a text, notions of geometry, algebra and trigonometry, differential and integral calculus of functions with one or more variables, differential equations of the first and second order. General physics knowledge that is acquired during the Physics 1 and Physics 2 courses of the bachelor degree in mathematics, and in particular the fundamental laws of electrostatic and magnetostatic fields.

Syllabus	
Course contents	**1. Electromagnetic induction:** Review of the laws of the static electric and magnetic fields. Faraday's law. Lenz's law. Origin of the induced electromotive force. Induction phenomena on moving circuits: Lorentz force;

	bar in motion on the tracks, coil in rotation in a uniform and stationary magnetic field. Induction phenomena due to variations of the magnetic field over time: induced electric field. Faraday's law in differential form. **2. Maxwell's equations:** Extension of Ampere's law to dynamic situations: displacement current. Ampere-Maxwell law. Fundamental equations of electromagnetism. **3. Electromagnetic waves:** Equation of electromagnetic waves. E and B fields in a plane wave. Plane waves in space. Energy transported by electromagnetic waves. Definition of the Poynting vector and its properties. Sinusoidal plane waves. Spherical and cylindrical waves. Momentum carried by an electromagnetic wave. Radiation pressure. Spectrum of electromagnetic radiation. **4. Reflection and refraction of plane waves:** Rays of light. Laws of reflection and refraction. Huygens principle and laws of reflection and refraction. Fermat's principle and laws of reflection and refraction. Total reflection. **5. Optics and Maxwell's equations:** Equation of electromagnetic waves in the presence of homogeneous linear media. Reflection and refraction of electromagnetic plane waves. **6. Interference and diffraction:** Introductory concepts on interference. Interference produced by two coherent sources. Coherent sources. Young's device. Interference produced by N coherent sources. General information on diffraction. Fraunhofer diffraction produced by a slit. Fraunhofer diffraction produced by a circular aperture. Resolving power of a circular aperture. Notes on diffraction gratings and X-ray diffraction. **7. Principles of special relativity:** Introduction to Lorentz transformations. Galileo's transformations. Galilean relativity and Maxwell's equations. A principle of relativity only for mechanics? Interferometers and aether entrainment. Starlight aberration. Einstein's principle of relativity. A simple example of a Lorentz transformation. The restricted Lorentz group. Matrix formalism and Minkowski metric. Relativistic kinematics. Length contraction. Time dilation and proper time. Relativistic composition of velocities. The phenomenon of aberration. Dilation of the lifetime of cosmic muons. Relativistic dynamics. Relationships between momentum, speed and energy. Total energy and mass energy, equivalence between mass and energy, relationship between momentum and energy. Experiment by W. Bertozzi. **8. Principles of quantum mechanics.** Thermal radiation, black body. Planck's law. Photoelectric effect. Compton effect. Pair production. Spectral lines of the hydrogen atom. Bohr's model of the atom. Material waves, de Broglie relation. Complementarity principle. Uncertainty principle, the Schroedinger equation.
Reference books	M.T.Chiaradia, L. Guerriero, G. Selvaggi: Fisica II: elettromagnetismo, Editrice Adriatica. M.T.Chiaradia, L. Guerriero, G. Selvaggi: Fisica II: onde elettromagnetiche, Editrice Adriatica. M. Gasperini, Manuale di relatività ristretta, Springer, capitoli 1, 2, 3 e 4 Vincenzo Barone, Relatività: principi e applicazioni, Bollati Boringhieri

	Mazzoldi, Nigro, Voci, Elettromagnetismo e Onde, Edises, II edizione, cap. 15
Additional course materials	Educational material (slides, short essays) uploaded to the Teams channel
Repository	

Expected learning outcomes	
Knowledge and understanding	The fundamental concepts of electromagnetism, electromagnetic waves, physical optics, special relativity and quantum mechanics. Ability to critically relate different fields of physics.
Applying knowledge and understanding	Ability to identify essential elements of a phenomenon, in terms of order of magnitude and level of approximation required. Ability to set up and solve problems related to classical electromagnetism, physical optics, special relativity and quantum mechanics. Ability to apply the acquired skills learned to a large variety of concrete physical situations, from electronics to astrophysics.
Soft skills	*Making judgements*: Ability to evaluate the coherence of logical reasoning used in the description of a physical process. Ability to identify the right tools and techniques to deal with the analysis of physical systems. Ability to recognize the variety and beauty of discoveries in electromagnetism, physical optics, special relativity and quantum mechanics. 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.
	Communication skills: Acquisition of the appropriate scientific language and the relative formalism, necessary for consulting and understanding the texts, exposing the acquired knowledge, describing, analyzing and solving problems.
	Learning skills: Acquisition of an adequate study method, supported by the consultation of texts and by the resolution of exercises and questions proposed periodically during the course, or by the application of the physics concepts learned to practical situations.

Teaching methods	
	The method of delivery of the lessons is frontal, with particular attention to the involvement of students in the educational dialogue. In some cases the projection of slides or short videos will be proposed. The lessons and exercises will be held in the presence, at the end of which, slide or other summary material of what was discussed in the classroom will be made available on the Teams platform, as pure support for a study to be carried out mainly on textbooks.

Assessment	
Assessment methods	The verification test consists of an oral exam, lasting approximately one hour, in which some of the topics covered in class will be critically discussed. The oral exam can also be taken in two exemptions, at the discretion of the student, one of which during the semester of lessons.
Evaluation criteria	• *Knowledge and understanding*: the degree of understanding of the physical laws studied and of the concepts discussed during the course will be verified. • *Applying knowledge and understanding*: the degree of understanding of how the physical laws and concepts studied during the course can be used to interpret natural phenomena and develop complex instrumentation will be verified. • *Making judgement*: the ability to interpret physical phenomena in

	terms of fundamental laws and the ability to use concepts to imagine possible future developments will be verified. • *Communication skills*: the ability to use the appropriate language and communication structures in the presentation of the main physics concepts covered during the course will be verified. • *Learning skills*: the ability to know how to organize oneself in learning the subject, in the organization of knowledge, in the critical approach, and any individual insights will be verified.
Grading policy	The exam consists of an oral test, during which 100% of the final evaluation score, expressed out of thirty, will be awarded. The exam is considered passed if a score of at least 18/30 is obtained. In the oral exam, the ability to illustrate the topics to other people with precision and methodological rigor, 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. The student must show mastery of the language, methodological rigor and have acquired the fundamental notions and concepts of the course. Assessment is based on the achievement of the intended learning objectives. To achieve a high evaluation, the student must have developed independent judgment and adequate capacity for argumentation and exposition. Honors are awarded in the case of a particularly brilliant presentation, independent insights by the student, an approach to the subject with a particularly developed critical spirit.

Further information	
	Attendance at the lessons is strongly recommended. For home study it is advisable to use the indicated textbooks, or other Physics textbooks that deal with the same topics and, only in the second instance and as a supplement, the notes taken during the lessons or the slides made available by the teachers.