UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

DIPARTIMENTO INTERATENEO DI FISICA

COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2024-2025*

ACADEMIC SUBJECT *Laboratory of Photonics*

General information	
Year of the course	1st
Academic calendar (starting and ending date)	2^{nd} semester: March – May 2025
Credits (CFU/ECTS):	6
SSD	FIS/03
Language	English
Mode of attendance	Compulsory

Professor/ Lecturer	
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Department and address	Dipartimento Interateneo di Fisica, Via Amendola 173, 70126 Bari (BA)
Virtual room	gjoifyk
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Mon & Wed from 3 to 4 pm, office and online

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
150	32	30	88
CFU/ECTS			
6	4	2	

Learning Objectives	Skills in modern geometrical and classical optics, laser beams characterization and shaping, both on theoretical and practical basis. Knowledge of light propagation in free-space and linear optical components.
Course prerequisites	Electromagnetism and waves, ray optics, laser fundamentals, differential calculus and complex functions

Teaching strategies	Frontal teaching using slides and blackboard. Laboratory activities: group work for the preparation for laboratory activities, the conduct of experiments, and the discussion and critical analysis of the results. Report of lab experiences
Expected learning outcomes in terms of	
Knowledge and understanding on:	o Understanding the scientific method, the nature, and the methods of research in Physics o Knowledge of the structure of matter, with particular attention to condensed matter and photonics applications o Advanced geometrical optics o Properties of Gaussian beam and the way to characterize it o Polarization optics o Statistical properties of light

	o Light propagation and Fourier optics o Designing tools for tailoring optical properties
Applying knowledge and understanding on:	o Ability to identify the essential elements of a phenomenon o Ability to use analogy to apply known solutions to new problems (problem solving) o Ability to use analytical and numerical mathematical computation tools o Criteria for choosing optical materials and components. o Criteria for choosing instrumentation for light beams characterization.
Soft skills	● **Making informed judgments and choices** o Ability to work with increasing levels of autonomy, including taking responsibility in project planning and managing facilities o Judge the value of acquired knowledge. Establish evaluation criteria and standards, both quantitative and qualitative o Compare, contrast, distinguish, describe novel technologies and the underlying physical phenomena ● **Communicating knowledge and understanding** o Competence in communication in Italian and English in advanced fields of Physics o Writing extended laboratory reports. o Preparing and presenting tutorial-type presentations. ● **Capacities to continue learning** o Acquisition of basic knowledge tools for continuous learning and knowledge updates o Critically review laboratory results.
Syllabus	
Content knowledge	***Matrix geometric optics and Gaussian beams*** Matrix geometric optics Elementary solutions of the Gaussian wave equation and beams ABCD matrices and beam shaping ***Vector optics*** Brief review of the e.m. theory of the light Linear, circular and elliptical polarization; Malus law Polarization and matrix representation (Jones and Muller matrices) Polarization by scattering and reflection, Fresnel relations Birefringence and waveplates Partial polarization (Stokes parameters, degree of polarization, Poincaré sphere) ***Interference and coherence*** General considerations and conditions for interference Interference between 2 beams of light and its applications (interferometric measurements and Optical Coherence Tomography) Interference between multiple beams and its applications (diffraction gratings, Fabry-Perot, antireflection coatings, interferential filters) Overview of Statistical Optics: function of mutual coherence, degree of coherence ***Fourier optics*** Brief review of Fourier transforms and linear systems Plane-wave and spatial harmonics Fraunhofer diffraction (single and double slits, circular slit, diffraction gratings) Fresnel Diffraction (openings and circular obstacles, Fresnel plate) Transfer functions and impulse-respone function Optical Fourier transforms and imaging Spatial filters ***Optical instrumentation*** Linear optical components and systems: main features and criteria for selection **Laboratory experiences** 1. Laser fluorometer (in CW) and construction of a spectrometer

	2. Polarization: Malus's Law and its consequences; use of waveplates and measurement of Stokes parameters 3. Michelson interferometer and low coherence interferometry: measurement of the refractive index of a medium; measurement of the coherence time of a LED; operating principle of OCT 4. Diffraction: single and double slit, circular slit, diffraction grating, spiral obstacle 5. Microscopy and Fourier optics
Texts and readings	G. Benenti, G. Casati, D. Rossini, G. Strini, Principles of quantum computation and information (World Scientific, 2019). M. A. Nielsen and I. L Chuang, Quantum computation and quantum information (Cambridge University Press, 2010).
Notes, additional materials	
Repository	

Assessment	
Assessment methods	Lab report and oral exam
Assessment criteria	● **Knowledge and understanding** Minimum: the properties of Gaussian beam and the way to characterize it, classification and usage of optical materials. Intermediate: materials' design tools for tailoring optical properties. Optimal: maths of wave propagation in transparent media. ● **Applying knowledge and understanding** Minimum: critical analysis and accurate presentation of laboratory activity Intermediate: comprehensive review of state-of-art Optimal: comparison of experimental data with numerical simulations ● **Autonomy of judgment** Minimum: correct estimation of experimental uncertainties. Intermediate: motivated choice of materials and components for the purpose. Optimal: identification of the optimal setup for a given measurement. ● **Communicating knowledge and understanding** Minimum: compliance with timing and template of reports and presentation. Intermediate: cogency of argumentation. Optimal: skillful presentation of state-of-art and perspective studies
Final exam and grading criteria	20% lab reports, 80% oral exam (20% for each of the above criteria)
Further information	
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