



Program of *OPTICS*

Prof. Eugenio FAZIO

Electromagnetic waves and light

Maxwell equations and EM wave equation. Spherical and plane waves. Frequencies and wavelengths of EM waves. Microscopical interpretation of the refractive index. Active and reactive polarisation and the complex refractive index. Sellmeyer equation for the refractive index dispersion. Abbe number and Abbe space for glasses. Poynting vector and light energy. Lightning quantities.

Reflection and refraction

Fermat "minimal action" principle and Snell Law. Fresnel coefficients. Critical angle and total reflection regime. Evanescent waves and Goos-Hänchen phase shift. Geometrical interpretation of optical fibres and waveguides. **Laboratory experience: measuring the refractive index of different materials.**

Geometrical Optics

Short wavelength approximation. Reflection and mirrors. Refraction and dioptric surfaces. Thin lenses. Ray-tracing and ABCD matrices. Thick lenses and principal planes. Centred optical systems. Pupils/stops/f-number/numerical aperture. Vignetting and *cosine-to-the-fourth-power* law. Principal optical aberrations. Chromatic aberration and Achromatic doublet. **Laboratory experience: measurement of lens focal length and aberrations.**

Interference and interferometers

Interference of 2 co-propagating waves. Interference of 2 contra-propagating waves: stationary waves and resonators. Fabry-Perot resonator. Optical fibres as transverse resonators. Multilayer interferent systems. Design of dielectric mirrors and band-pass filters. Spatial and temporal interference. Young's experiment. Wave beating. Continuous waves and pulses. Phase and group velocities.

Diffraction

Huygens-Fresnel principle and integral. Near field regime and Fresnel Integral. Far field and Fraunhofer integral. Diffraction from a slit. Focusing limit of a lens. Diffraction from a stop. Diffraction from a grating. Harmonic and anharmonic gratings. Nano-optics.

Anisotropic optics

Anisotropic crystals. Index Ellipsoid. Uniaxial and biaxial crystals. Dichroism. retardation plates.

Nonlinear Optics

Nonlinear response. Anharmonic oscillator. Second order effects. The nonlinear optical tensor. Optical harmonic generation. Parametric effects. The Pockels electro-optic effect. Electro-optic modulators. Photorefractivity and self-assembling optical structures. Spatial solitons and solitonic waveguiding. Smart systems, Machine Learning and Photonic Artificial Intelligence.

GENERAL INFORMATION

e-mail: eugenio.fazio@uniroma1.it

Information on the course: <http://www.sbai.uniroma1.it/users/fazio-eugenio> and on [GOOGLE CLASSROOM](#): course code **yh6ogjx** (register with the institutional e-mail address: surname.matricola@studenti.uniroma1.it)

Reception for explanations: for an explanation meeting on unclear points send an e-mail (write RICEVIMENTO in the object)

Teaching materials:

Copies of the pages written on the blackboard will be available on the classroom page of the course under “*Lavori in Corso*”

handouts written by the professor

REFERENCE BOOKS

F. Gori, *Elementi di Ottica*, ed. Accademica

P. Mazzoldi/M.Nigro/C. Voci, *Elementi di Fisica-Onde*, EdiSES

K.D. Moller, *Optics*, Springer

A. Yariv, *Quantum Electronics*, John Wiley & Sons

Wyszecki & Stiles, *Color Science*, Wiley Classics Library

H. Zappe, *Fundamentals of Micro-Optics*, Cambridge University Press

CLASS SCHEDULE – aula 17 @ San Pietro in Vincoli Faculty (Via Eudossiana 18)	
WEDNESDAY	15:00 - 17:00
THURSDAY	10:00 - 13:00

LADIFI Laboratories –Via del Castro Laurenziano 7°, 1st floor
<p>This year two laboratory experiences will be introduced, one on Snell's law and one on lenses. The tests will be held at the LADIFI laboratories. The dates will be decided together in class based on the progress of the course and the availability of the laboratories.</p> <p>At the end of the tests a report will be produced: based on the score obtained, the part carried out in the laboratory may be removed from the final exam.</p>

EXAMS		
SUMMER SECTION	JUNE 12, 2025	BOOKING DEADLINE ON INFOSTUD: JUNE 10, 2025
	JULY 14, 2025	BOOKING DEADLINE ON INFOSTUD: JULY 10, 2025
FALL SECTION	SEPTEMBER 4, 2025	BOOKING DEADLINE ON INFOSTUD: SEPTEMBER 1, 2025

MASTER Thesis: topics for stages are available on request on the following topics: plasmonic artificial intelligence; all-optical memories and machine learning; all-optical convolutional neural networks; optical system design (in collaboration with a private company). Please contact the professor for details.