



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## SYLLABUS DEL CORSO

### Ottica Geometrica e Oftalmica con Laboratorio

2021-1-E3002Q033

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#### Aims

Knowledge of the main concepts of geometric and ophthalmic optics (refraction, reflection, optical lenses, mirrors, optical systems, etc.)

#### Contents

The course concerns the basic concepts of geometrical optics in Gauss approximation and third order approximation

#### Detailed program

##### Introduction

Nature and light propagation

Waves and rays

Huygens Principle

Electromagnetic spectrum:

Considerations on optical properties of materials: refractive index and its dependence on the frequency of electromagnetic radiation

## Mathematical representation of waves

Mathematical representation of a wave from an initial impulse

Harmonic wave: definition of amplitude, wavenumber, wavelength, angular frequency, time period, frequency, phase

## Photometry

Radiant and luminous flux

Light intensity of a source

Illumination of a surface

sources of light and Lambert's law for diffuse surfaces

Emission of extended sources

## Reflection and refraction of light on a flat surface

Light reflection and demonstration according to Huygens's construction

Light reflection and demonstration according to Huygens construction

Principle of Fermat

Demonstrations of the laws of reflection and refraction of light according to the principle of Fermat

Reflection of spherical waves on flat surfaces and images formed by flat mirrors

Reflection of spherical waves on flat surfaces, apparent depth of objects, and apparent astigmatism

Atmospheric refraction and mirage

lamina with flat and parallel faces: deviation and shift of the rays

Total internal reflection and limit angle

Prisms with total reflection

Prisms: prismatic deviation and minimum prismatic deviation, refractive index and minimum deviation angle

Condition for light to emerge from a prism

Prismatic power and prismatic dioptre

Chromatic dispersion of light for refraction: dispersive power definitions and number of Abbe

## Reflection and refraction of light on a spherical surface in approximation of Gauss

Reflection of light on a spherical surface

Convex and concave spherical mirrors, main optical axis, focal point and focal distance, center and radius of curvature

Graphic construction method of images produced by mirrors

Images produced by spherical mirrors

Law of conjugated points for the spherical mirror and demonstration

Transversal Linear Magnification for Spherical Mirror and Demonstration

Longitudinal linear magnification

Comparison between spherical aberration and astigmatism of spherical mirrors and parabolic mirror

Refraction of light on a spherical surface

Concave and convex spherical diopters, main optical axis, focal points and focal lengths, center and radius of curvature

Graphic method to find images produced by diopters

Formation of images produced by spherical diopters

Law of conjugated points for spherical diopter and demonstration

Transverse linear magnification law for spherical diopter and demonstration

### Spherical lenses

Converging or divergent lenses, focal points and focal distances, optical center, curvature centers, planes and main points

Graphic method to find images produced by thin or thick lenses

Law of conjugated points for thin or thick lenses and demonstrations

Gaussian shape and Newtonian shape of the lens equation and graphic representation

Transverse linear magnification law for thin or thick lenses and demonstrations

Optical equation for thin or thick lenses that are immersed in air

Generalization of optical equation for lenses not necessarily in air

Longitudinal linear magnification

Power of thin lenses and diopter

Thin lens power (nominal, effective, frontal)

### Lens-eye

Eye models

Eye, visual defects and correction

Features of retinal images: their size and angle of subject objects with the eye

Definition of visual acuity, fraction of Snellen and calculation of the magnitude of the optotypes

Magnifying glass and angular magnification

### Optical systems

Focal distance and power of optical systems and demonstration

System consisting of two thin lenses

System consisting of two thin lenses that are in contact with each other

Microscope: optical scheme and angular magnification

Astronomical telescope: optical scheme and angular magnification

Galilean telescope: optical scheme and angular magnification

Diaphragm and pupils in optical systems (eg astronomical telescope)

Field of view (eg astronomical telescope), depth of field

Focal point,  $f$  /, aperture, brightness (eg astronomical telescope)

### Aberrations of lenses and mirrors

Series of trigonometric functions and monochromatic aberration theory (third order)

Introduction to Seidel Coefficients

Longitudinal and transverse spherical aberration, minimal confusion, caustic, diaphragm, shape factor

Coma: form factor, aplanatic systems

Astigmatism of oblique beams

Field curvature

Distortion

Axial and lateral chromatic aberration

Zernike wavefront aberration and polynomial function

Laboratory experiments on refraction/reflection, prisms and optical lenses, mirrors, optical systems, lens aberrations

## **Prerequisites**

Basic mathematical notions contained in chap. 1 of the text of R.C. Davidson, "Mathematical methods for an introductory course in physics", ed. EdiSES (Italian edition edited by F. Madonia), i.e.:

powers of ten, negative exponents, prefixes, calculation with powers of ten, orders of magnitude, fractional exponents, algebraic equations, systems of equations of first degree, equations of second degree, binomial development.

On the first day of class, the teacher advises students to carry out a written test (which provides them) with questions on the previous topics, on the interpretation of graphs of simple functions in the Cartesian plane, on the use of units of measurement in physics and on related topics. The teacher corrects the tests carried out by the students in order to give them feedback on their preliminary knowledge needed for the course.

## **Teaching form**

The course includes 6 credits of lectures and 2 laboratory credits. Attendance at laboratory lessons is required.

During the Covid-19 emergency period, lectures and laboratory activities will take place in a mixed way: partial attendance and recorded lessons.

## **Textbook and teaching resource**

- F.W. Sears, "Ottica", Ed. CEA
- Notes

provided by the teacher through the University e-learning platform

- laboratory traces provided by the teacher through the University e-learning platform

- recorded lessons provided by the teacher through the University e-learning platform

## **Semester**

first semester

## **Assessment method**

The test consists of a written test and an oral test (with evaluation of a personal laboratory notebook to be presented to the oral exam).

Only students who were present during the laboratory activities have access the written test. On the day set for the exam session, students will be asked to answer a questionnaire consisting of 15 written questions. Some questions are multiple-choice, other questions are open, others require a graphic construction of images produced by lenses or mirrors, or similar questions. Students who have provided at least 10 correct answers are included in the oral exam calendar.

In the Covid-19 emergency period, exams will be held electronically using the WebEx platform.

No ongoing tests are planned.

The student can perform a kind of self-assessment during the hours of the laboratory activities as the experiences to be carried out cover topics already seen during the hours of lectures.

The exam can be done in English. For the written test, the student must expressly request it to the teacher at least one week in advance of the exam date.

## **Office hours**

appointment to be agreed via email

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