UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Geometric and Ophthalmic Optics and Laboratory

2526-1-E3006Q006

Aims

The objectives fall within the area of "Basic education in mathematics, physics, and chemistry" and refer to the following Dublin Descriptors:

1 – Knowledge and understanding

- Acquire knowledge and understanding in the area of basic education in physics
- Provide foundational knowledge specific to geometric and ophthalmic optics (reflection, refraction, lenses, mirrors, optical systems, etc.)

2 – Applying knowledge and understanding

- Acquire skills in applying the scientific method, which is essential both for understanding the topics of the course and for applying them to professional topics
- Develop the ability to fully understand the optical principles underlying instruments and devices used in optometric practice and contact lens application, as well as the optical principles of the visual system

3 – Making judgements

- Develop the ability to reflect independently on the course content in order to acquire autonomous judgement

4 – Communication skills

- Acquire communication skills in the fields of basic physics, optics, and optometry

5 – Learning skills

- Develop the ability to reflect independently on the course content in order to acquire learning skills in view

of future developments in the field

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
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 dioptry
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 convex 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)

The 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
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, opticalte 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 asks the students to carry out a writtenself-assessment test 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.

Teaching form

The teaching activity is provided in Italian.
The course corresponds to 8 credits, 2 of them corresponding to laboratory credits. Attendance at laboratory lessons is mandatory.
The details of the expected activities are:

- 38 hours of lessons in person;
- 4 hours of lessons at distance
- 24 hours of laboratory activities in person (attendance is mandatory)

Textbook and teaching resource

- F.W. Sears, “Ottica”, Ed. CEA
- notes provided by the lecturer through the University e-learning platform
- laboratory traces provided by the lecturers through the University e-learning platform
- videos of the lessons provided through the University e-learning platform

Semester

first semester

Assessment method

The test consists of a written test and an oral test.
The purpose of the written test is the extensive verification of the preparation on the exam program.
The purpose of the oral exam is to verify the ability to autonomously think and discuss on the topics of the program and the communication ability.

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. The oral exam in an interview on the topics discussed during the course (with also an evaluation of a personal laboratory notebook to be presented to the oral exam).

The student can perform a kind of self-assessment during the hours of the labortory activities as the experiences to be carried out cover topics already seen during the hours of lectures. On the e-learning page of the course, some questions are reported which are similar to the questions expected during the written exam.

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

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING