



Course guide

240407 - 240407 - Technology of Light

Last modified: 16/05/2023

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 3.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: ROBERTO MACOVEZ

Others: ROBERTO MACOVEZ

REQUIREMENTS

Participants must have passed the exams of the courses "Àlgebra Lineal" and "Mecànica Fonamental", and they have to have attended the lectures of the course "Electromagnetisme"

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

2. Capacity to solve mathematical problems that can appear in engineering . Aptitude to apply knowledge about: linear algebra; geometry; differential geometry; differential and integral calculus; differential equations and derived partial equations; numerical methods; numerical algorithm; statistics and optimisation.
3. Knowledge of electronics fundamentals.
4. Understanding and dominion of basic concepts on mechanics, thermodynamics, fields and waves and electromagnetism laws and their application to solve engineering problems.

Transversal:

1. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

TEACHING METHODOLOGY

Theory classes
Exercise clases and description of applications
Audiopresentations of some of the course content

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, the students should be able to:

- identify the most appropriate approach (rays, waves, photons) for the description of the various phenomena that involve light;
- use the complex notation for describing waves and solving differential equations;
- find the solution to problems of geometric and wave optics, in particular involving the interaction of a planar wavefront with simple optical components (lenses, prisms, mirrors, gratings, etc.);
- describe the working principles behind image-forming optical sytems, lasers, semiconductor optoelectronic devices, and telecommunication systems
- write the rate equations for a laser and calculate its steady-state behavior
- evaluate the intrinsic limitations of optical instruments and identify alternative strategies to circumvent them; discuss different tools for the analysis and processing of images
- describe the physical mechanism behind human vision and the challenges for artificial vision



STUDY LOAD

Type	Hours	Percentage
Hours medium group	30,0	40.00
Self study	45,0	60.00

Total learning time: 75 h

CONTENTS

Electromagnetic waves and optical phenomena

Description:

- Maxwell's equations and electromagnetic wave equations; invariance of the frequency, Snell's law, vacuum wavelength and the electromagnetic spectrum
- The mathematics of optical waves: plane and spherical waves, complex notation; propagation of plane waves, (linear) light polarization
- Classical sources of radiation: electric-dipole antenna (emitter and receiver), the microwave, the synchrotron
- Optical properties and phenomena in material media and at their interfaces; complex refractive index, group and phase velocity, scattering; reflection, refraction, mirages, dispersion, interference and diffraction; polarizers; antireflection coatings; negative-index metamaterials
- waveguides, optical fibers, telecom optics

Developed skills: CE1, CE2

Specific objectives:

At the end of the first half of the course, students will be able to describe wave phenomena of light identify, to use the complex notation for describing waves and their superposition and solving differential equations; to calculate interference patterns and frequency spectra; and determine the propagation of light through materials, the reflection and refraction of light at their interfaces, and describe the propagation of light inside waveguides and optical fibers.

Related activities:

- First round of homework problems (10% of the final mark)
- Second round of homework problems (10% of the final mark)
- Midterm Exam (35% of final mark)

Full-or-part-time: 38h

Theory classes: 9h 30m

Practical classes: 7h 30m

Self study : 21h



Images, laser and optoelectronics

Description:

- Photons, spontaneous and stimulated emission, absorption
 - Quantum light sources: thermal sources; amplification, laser theory, types and applications of lasers
 - Optoelectronic devices; photodiode, light-emitting devices (LED) and solar cells; detectors and displays
 - Optical microscope, telescope, resolution limit; evanescent waves and near-field microscopy (SNOM)
 - Dark-field microscopy; holografy
 - Human and artificial vision
 - Image analysis (Fourier filters)
- Developed skills: CE11, CE2

Specific objectives:

At the end of this section the students will know how to describe the working principles behind semiconductor optoelectronic devices, and their application in telecommunication systems; write the rate equations for a laser and calculate its steady-state behavior; determine the effects induced by optical fields of high intensity; evaluate the intrinsic limitations of optical instruments; compare different techniques for the acquisition and processing of images; describe the physical basis for human vision and the open challenges towards artificial vision

Related activities:

- Third round of homework problems (10% of final mark)
- Final Exam (35% of final mark)

Full-or-part-time: 37h

Theory classes: 7h 30m

Practical classes: 6h 30m

Self study : 23h

ACTIVITIES

CONTINUOUS ASSESSMENT EXAM (MIDTERM EXAM)

Description:

Two-hour (estimated total time) exam on the contents of topic 1 and part of topic 2.

Specific objectives:

In this exam the students will be required to solve some optics exercises, stating with clarity the approach used. This will allow the teacher to verify the students' knowledge of the fundamental concepts of electromagnetic optics.

Material:

transparencies used by teacher for the theory and exercise classes; problems solved in class and autonomously at home; textbook.

Delivery:

Evaluated material: exam handed in by student (electronically)

Full-or-part-time: 12h

Self study: 12h



Handed-in Homework (3 rounds)

Description:

The students will have to hand a series of homework problems, similar to the ones solved in the classroom (two or three for each round).

Specific objectives:

Students will learn to describe optical phenomena in terms of the theory explained during class; this will be helpful for them to pass the midterm exam.

Material:

Slides used by teacher in class; problems solved in class; textbook.

Delivery:

Evaluated material: handed-in homework

Full-or-part-time: 4h

Self study: 4h

GRADING SYSTEM

The final mark will be a weighted average over the marks obtained in the mid-term, and final exams, as well as on the handed-in homework. The relative weight of each of these marks for the final mark is reported in the table below:

Mid-term exam 35%

Homework 30% (10%+10%+10%)

Final exam 35%

If a student scores higher than 6 out of 10 in her/his midterm exam, she/he is exempted from taking the final exam. The final mark, in such a case, will be calculated using the following weights:

Mid-term exam 70%

Homework 30% (10%+10%+10%)

This academic year 2019-2020, due to the exceptional situation, some of the classes will be replaced by audiopresentations, and the midterm exam and the final exam will be done and handed-in online.

BIBLIOGRAPHY

Basic:

- Smith, F. Graham. Optics and photonics : an introduction. 2nd ed. Chichester: John Wiley & Sons, 2007. ISBN 9780470017838.
- Hecht, Eugene. Óptica [on line]. 5a ed. Madrid: Pearson, 2017 [Consultation: 19/10/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=6557. ISBN 9788490354926.
- Hecht, Eugene. Teoría y Problemas de Óptica. México: McGraw-Hill, 1976. ISBN 9684222467.

Complementary:

- Cabrera, José Manuel. Óptica Electromagnética. Vol. 1: Fundamentos. 2ª Edición. Madrid: Addison-Wesley, 1998. ISBN 8478290214.
- Pedrotti, Frank L. Introduction to Optics. 3rd ed. San Francisco: Pearson Prentice-Hall, 2007. ISBN 9780131499331.
- Saleh B.E.A., Teich, M.C.. Fundamentals of Photonics. 2nd. New York: John Wiley & Sons, 2007. ISBN 9780471358329.

RESOURCES

Other resources:

- Book on-line: J. Peatross, M. Ware, Physics of Light and Optics, 2015 edition. Available at: <http://optics.byu.edu/textbook.aspx> />
- The last chapters of the book by P. Lorrain and D. R. Corson, Campos y ondas electromagnéticas. 5ª Ed., Selecciones Científicas (1990), contain a lot of material on antennas and electromagnetic waves. Several copies are available in the ETSEIB library.