Course guide
230550 - INTRO - Introduction to Photonics: Optics and Lasers

Last modified: 11/04/2025

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

Degree: MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Compulsory subject).
MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).

Academic year: 2025 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: CRINA MARIA COJOCARU

Others: Primer quadrimestre:
VERÓNICA AHUFINGER BRETO - 10
DAVID ARTIGAS GARCIA - 10
CRINA MARIA COJOCARU - 10

PRIOR SKILLS

35 students

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE1. Demonstrate the understanding of physical fundamentals of classical optics and light-matter interaction
CE2. Demonstrate the understanding of the peculiarities of the quantum model for light-matter interaction.
CE3. Know the fundamentals of laser physics, the types of lasers and their main applications.

Generical:
CG2. Ability to modeling, calculate, simulate, develop and implement in research and technological centers and companies, particularly in research, development and innovation tasks in all areas related to Photonics.
CG4. Ability to understand the generalist and multidisciplinary nature of photonics, seeing its application, for example, to medicine, biology, energy, communications or industry

Transversal:
1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

3. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.

2. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

4. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context
CB7. Students should know how to apply the knowledge acquired and their problem-solving ability in new or little-known environments within broader (or multidisciplinary) contexts related to their area of ¿¿study.

TEACHING METHODOLOGY

Lectures
Exercises and applications
Activities

LEARNING OBJECTIVES OF THE SUBJECT

This course presents a general overview of the world of Photonics, introducing the fundamental aspects and physical phenomena concerning light and, especially, its interaction with matter (excluding pure propagation phenomena in uniform materials, in particular beam propagation, image formation and Fourier Optics, as they are considered in the course "Beam propagation & Fourier Optics"). At the same time, in many of the subjects the state-of-the art in research and the variety of applications of Photonics in Science & Technology will be pointed out.
The course is given in the first semester, to allow the student better follow the different Master courses, in any of the itineraries he/she can choose)

STUDY LOAD

Type	Hours	Percentage
Hours large group	40,0	32.00
Self study	85,0	68.00

Total learning time: 125 h

CONTENTS

1. Light

Description:
1.1. Classical properties of ligth: electromagnetic approach (review).
Wave equation and electromagnetic waves. Monochromatic solutions (plane waves, spherical waves, optical beams,…); non-monochromatic solutions (temporal coherence, optical pulses, light velocities, dispersion).

1.2. Quantum properties of light (introduction)
Quantization of the electromagnetic field. Photons, particle character and states of light. Uncertainty and measurement. Squeezing, vacuum field, concepts of qubit and entanglement.

Full-or-part-time: 10h
Theory classes: 10h

2. Light-matter interaction: basic physical phenomena.

Description:
2.1 General aspects of linear ligth-matter interaction phenomena at microscopic scale. Clasical and semiclasical approach, Einstein model. Consequences at macroscopic scale. Calculation of the refractive index.
2.2 Specific physical phenomena arising in the linear interaction of light with the different types of materials: dielectrics, semiconductirs, metals, structured media and confined materials.
2.3 Effects due to the linear momentum of light: radiation force and presure, cooling and trapping of atoms, optical tweezers
2.4 Introduction to nonlinear optics. General aspects

Full-or-part-time: 12h
Theory classes: 12h

3. Light-matter interaction: photoemiters, LASERS and photodetectors.

Description:
3.1. Photoemitters by spontaneous emission: thermal radiation, discharge lamps, LEDs.
3.2. Photoemitters by stimulated emission: LASERS
3.3. Photodetectors: power (thermal, quantum), position & image photodetectors. Special detection techniques.

Full-or-part-time: 10h
Theory classes: 10h

GRADING SYSTEM

- Partial exams and tests (30%)
- Assignments and reports (30%)
- Final exam (30%)
- Attendance to classes, seminars and laboratory visits (10%)

BIBLIOGRAPHY

Basic:
- Saleh, B.E.A.; Teich, M.C. Fundamentals of photonics. 3rd ed. Hoboken: John Wiley & Sons, 2019. ISBN 9781119506874.
- Kasap, Safa O. Optoelectronics and photonics: principles and practices. 2nd. Pearson, 2012. ISBN 9780273774174 (INT. ED.).
- Svelto, Oracio. Principles of lasers [on line]. 5th. Springer, 2010 [Consultation: 02/05/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=973138. ISBN 9781441913012.
- Loudon, R. The quantum theory of light. 3rd. Oxford Clarendon Press, 2000. ISBN 9780198501763.
- Trull, Jose. Photonics : an introductory course [on line]. Barcelona: Iniciativa Digital Politècnica, 2021 [Consultation: 28/07/2022]. Available on: https://upcommons.upc.edu/handle/2117/338169. ISBN 9788498808919.