

Degree in Physical Engineering
Course: Photonics (6 credits ECTS)

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Course Program

1. Fundamental properties of light

- 1.1 Classical description of light waves
- 1.2 Basic solutions to the scalar wave equation
- 1.3 Vector representation of light waves. Polarization
- 1.4 Conservation of energy. Intensity
- 1.5 Momentum relations and radiation pressure

2. Basic models for optical beams

- 2.1 Helmholtz equation for optical beams
- 2.2 Paraxial wave equation for optical beams
- 2.3 Basic solutions to the paraxial wave equation
- 2.4 Basic properties of Gaussian beams
- 2.5 The effect of a lens on a Gaussian beam
- 2.6 General solutions to the paraxial wave equation

3. Light emission and light-matter interaction

- 3.1 Light emission from a dipole
- 3.2 Radiation properties of harmonic dipoles
- 3.3 Interaction of a single atom with an incident light field
- 3.4 Maxwell equations in macroscopic media
- 3.5 Energy relations in material media

4. Crystal Optics

- 4.1 Normal modes of propagation in birefringent media
- 4.2 Polarization state of the normal modes
- 4.3 Ray propagation in uniaxial crystals
- 4.4 Applications of wave propagation in uniaxial crystals

5. Light pulse propagation

- 5.1 Mathematical description of light pulses
- 5.2 Pulse duration and bandwidth
- 5.3 Instantaneous frequency and chirp
- 5.4 Optical pulse propagation in dispersive media

6. Basic diffraction phenomena

- 6.1 Angular spectrum representation of optical beams
- 6.2 The concept of spatial frequency
- 6.3 The connection between the angular spectrum representation and the scalar Rayleigh-Sommerfeld diffraction theory
- 6.4 Diffraction theory in the Fresnel and Fraunhofer approximation
- 6.5 Fourier transforms by lenses: Introduction to image processing
- 6.6 Resolution limit in optical systems
- 6.7 Diffraction from an array of periodic elements

7. Applications of photonics

Evaluation:

There will be two exams:

- A first partial at mid semester, covering the contents studied up to this point, with a weight of 40% of the total mark of the course.
- A second exam at the end of the course. For this second exam there are two options:

Option A: Second partial exam covering the contents of the program taught during the second part of the course and with a weight of 50% of the total mark.

Option B: There is also the option to take a Final exam, with the whole contents of the course and with a weight of 90% of the total mark.

Final mark:

Option A:

First partial (40%) + Second partial (50%) + Work on photonics applications (10%)

Option B:

Final Exam (90%) + Work on photonics applications (10%)

Bibliography:

J. Trull. Photonics. An introductory course. 2021. Ed. UPC Grau.
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