Course guide
820082 - FA - Applied Photonics

Last modified: 14/06/2023

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

Degree: BACHELOR'S DEGREE IN BIOMEDICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ENERGY ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: Muriel Botey

Others: Segon quadrimestre:
MURIEL BOTEY CUMELLA - T11, T12

PRIOR SKILLS

Students should have the prior knowledge of mathematics and physics acquired in the initial phase.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
1. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.

TEACHING METHODOLOGY

The subject is divided into expository classes (30%) group work in the laboratory practices (20%) individual work of exercises, problems and computer simulations (25%) and final group expository presentation (25%)

LEARNING OBJECTIVES OF THE SUBJECT

The field of Photonics involves the generation and control of light (photons) for applications. The main objective of the subject is to study the technological applications of light based on the understanding of the properties of light that are the basis of photonic systems. Specifically, the different light sources will be studied and especially the differnt kinds of lasers, their industrial applications, the propagation, transmission and guidance of light ... An overview of the technological applications of photonics, which are virtually unlimited!

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	30.00
Hours small group	15,0	10.00
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

-Unit 1: The nature of light and its propagation: optical tweezerss and antennas.

Description:
1. Electromagnetic waves: Maxwell's equations. Speed â□□â□□of light. Energy and momentum. (Optical tweezers)
2. Electromagnetic spectrum.
3. Generation of electromagnetic radiation: Electric dipole radiation. Rayleigh diffusion. (Antennas)
4. Electromagnetic waves in dielectric materials.
5. Propagation of light. Fermat's principle. Wavefronts and light beam. Huygens' principle.
6. Reflection and refraction: Snell's law. Total reflection. Fresnel Equations (Optical Fibers)
7. Propagation in non-homogeneous media

Related activities:
Laboratory sessions:
1-Propagation in a medium with non-uniform refractive index
4-Spectroscopy with a prism

Full-or-part-time: 9h
Theory classes: 3h
Laboratory classes: 6h

-Unit 2: Light sources: solar enegy, bulbs, LEDs and Lasers.

Description:
1. Introduction. Sources of electromagnetic radiation
2. Black body radiation. Thermal emitters. (Sunlight)
3. Atomic structure of matter. Radiation-matter interaction. The photo. (Photovoltaic solar energy)
4. Band structure of semiconductors. Non-thermal emitters. (LED, halogen lights, ..)
5. Principles of laser operation: Basic elements of the laser.
6. Laser cavities. Modal selection and temporal control.
7. Characteristics of laser light.

Full-or-part-time: 5h
Theory classes: 5h

-Unit 3: Polaritzation: filters and 3D vison.

Description:
1.Concept of polarization. Types of Polarization. Polarizers. Malus law. Polarization by reflection and diffusion.
2. Fresnel coefficients. Brewster angle
3. Dichroism: Dichroism. Polaroids. (Glasses, filters, ..)
4. Binocular vision. Stereoscopy. Autostereoscopy (3D cinema)
5. Birefringence. Induced birefringence. Birefringent polarizers. Delay sheets. (Insulators. Optical modulators)
6. Photoelasticity. Interference colors. (Polarimetry)

Related activities:
Laboratory Session:
2-Polarization of light

Full-or-part-time: 9h
Theory classes: 6h
Laboratory classes: 2h
Guided activities: 1h

-Unit 4: Geometrical optics, from microns to light years: microscopes, satellite dishes, telescopes, ...

Description:
1. Representation of optical systems.
2. Diopters within the paraxial approach.
3. Slow down. Convergent and divergent lenses. Focal shots. Image formation. Coupling of two thin lenses.
4. Optical aberrations.
5. Mirrors: Flat mirror. Spherical mirrors. Parabolic mirror. (Satellite dishes)
6. The human eye. Corrections. (Eye Surgery)
7. Optical instrumentation. (Telescopes, microscopes, ...)
8. Prisms.Changing the image orientation. (Binoculars)

Related activities:
Laboratory Sessions:
3-Construction of optical systems
4-Dispersion. Spectroscopy with a diffraction grating

Full-or-part-time: 9h
Theory classes: 6h
Laboratory classes: 3h

- Unit 5: Light interferences: nanometric indirect measurement, color filters, ...

Description:
1. Electromagnetic wave interferences. Temporal and spatial coherence.
2. Wavefront Division Interferometers: Young's Experience. Other configurations. Applications.
3. Amplitude division interferometers: Michelson interferometer. Mach-Zehnder interferometer. Fringes of Pohl and Fizeau.
4. Multiple beam interference: Fabry-Perot interferometer. (Precision metrology)
5. Multilayer optics (Interference filters, mirrors, ...)

Related activities:
Laboratory Session
5-Interferences and difraction

Full-or-part-time: 7h 20m
Theory classes: 4h 20m
Laboratory classes: 2h
Guided activities: 1h

-Unit 6: Difraction and holography.

Description:
1. Concept of diffraction
2. Fraunhofer diffraction: One-dimensional slit. Rectangle. Circular opening. Two cracks. Diffraction network
3. Spectroscopy with diffraction grids: Spectral range and resolution power. Types of networks. (Spectrometry. Analysis of crystals and particles. Acousto-optical modulators)
4. Fresnel Diffraction: Fresnel approximation. Fresnel zonal plate
5. Holography. Basics of holography. Types of Holograms. (Security)

Related activities:
Laboratory Practices:
5-Interferences and diffraction
4-Spectroscopy with a diffraction grating

Full-or-part-time: 9h
Theory classes: 6h
Laboratory classes: 3h

-Unit 7: Laser security

Description:
1.Effects of laser light on human tissues (eyes and skin)
2. Lasers' Classification
3. Laser safety and safety googles.

Full-or-part-time: 2h
Theory classes: 2h

-Unit 8: Optical characterization and Biophotonics

Description:
1. Photomedicine: therapeutic use of light. Neurophotonics. Surgery (vision, cancer). Dermatology
2. Diagnosis and Characterization with light: Microscopy, Fluorescence, Sensors (cytometry, nanosensors ...). Measuring devices at the Multiscale center of Barcelona

Full-or-part-time: 4h
Theory classes: 2h
Guided activities: 2h

-Unit 9: Laser material processing: cutting, welding, 3D printing, marking,...

Description:
1.Types of lasers: Gas lasers. Excimer lasers. Solid state lasers. Fiber lasers. Semiconductor lasers.
2. Melting process, evaporation. Ablation process.
3. Macroprocessing. Cutting and welding
4. 3D writing. Additive laser processing.
5. Laser marking: Features. Marking processes.
6. Microprocessing. Direct Laser Writing.

Full-or-part-time: 2h
Theory classes: 2h

-Unit 10: Optical communications. Optical fibers.

Description:
1.Waves guides. Types of waveguides.
2. Structure of optical communications.
3.Optical fibers. Single-mode and multimode fibers. Fiber attenuation. Dispersion. Information capacity. Evolution. Optical cables. Manufacture of fibers.
4.Optoelectronics. Silicon photonics.

Full-or-part-time: 2h
Theory classes: 2h

GRADING SYSTEM

10% Attendance and participation
20% Selected topic presentation
20% Exercises, problems and simulations
20% Laboratory Sessions
25% Final exam

EXAMINATION RULES.

The exam can be performed using a formulary and calculator.

BIBLIOGRAPHY

Basic:
- Saleh, Bahaa E. A.; Teich, Malvin Carl. Fundamentals of photonics. 3rd ed. New York [etc.]: John Wiley & Sons, cop. 2019. ISBN 9781119506874.
- Tipler, Paul Allen; Mosca, Gene. Física per a la ciència i la tecnologia [on line]. Barcelona [etc.]: Reverté, 2010 [Consultation: 07/05/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=6536. ISBN 9788429144321.
- Fowles, Grant R. Introduction to modern optics. 2nd ed. Nova York: Dover Publications, 1989. ISBN 0486659577.