Course guide
320031 - FOAE - Photonics. Optics Applied to Engineering

Last modified: 02/04/2024

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: BACHELOR'S DEGREE IN AUDIOVISUAL SYSTEMS ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN CHEMICAL ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN ELECTRICAL 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 TEXTILE TECHNOLOGY AND DESIGN ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: Ramon Herrero

Others: Ramon Herrero

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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.
2. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
3. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
4. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
5. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.

TEACHING METHODOLOGY

- Theoretical sessions and application exercises
- Laboratory sessions
- Works in groups on specific topics and presentations
- Autonomous study.

In the theoretical sessions we will introduce the bases of the subject, concepts, methods and results illustrating them with convenient examples to facilitate their understanding.
The properties of light and its applications are observed in the laboratory
The topics of group or individual work are chosen according to the interest of each student

LEARNING OBJECTIVES OF THE SUBJECT

-Photonics is the science and technology of photons and electromagnetic waves from gamma rays to radio, including X-rays, UV, visible and infrared light.
-Photonics supports the technologies of daily life, from telecommunications (fiber optics, Internet) to lighting technology (light bulbs, LEDs, Lasers) to consumer electronics (smartphones, laptops, barcode scanners, CD, DVD, remote control) to health (eye surgery, microscopy, tomography, medical instruments) to industry (cutting, welding and laser machining) to defense and safety (infrared camera, remote sensing) to entertainment (holography, laser shows) to explore the universe, etc .... The 21st century will depend as much on photonics as the 20th century depended on electronics.
-The objectives of the subject are on the one hand to know the basic properties of light and its application in the different branches of engineering and on the other hand to know the current photonic technologies.

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	20.00
Self study	90,0	60.00
Hours medium group	15,0	10.00
Hours small group	15,0	10.00

Total learning time: 150 h

CONTENTS

1: Nature and propagation of light

Description:
1.1 Electromagnetic waves
1.2. Radiation generation and electromagnetic spectrum
1.3. Propagation in dielectric materials, reflection and transmission
1.4. Propagation in non-homogeneous media
1.5. Applications: Laser telemetry, object detection, alignment, data readers, profilometers, detectors of position, speed and rotation

Related activities:
Theory
Applied exercises
Laboratory practice: propagation in homogeneous and inhomogeneous media

Full-or-part-time: 24h 30m
Theory classes: 5h
Practical classes: 2h 30m
Laboratory classes: 2h
Self study : 15h

2: Geometric optics and optic instruments

Description:
2.1. Optical systems and imaging
2.2. Optical instrumentation: Camera, telescope, microscope, confocal microscope, ...
2.3. Prisms and spectroscopy

Related activities:
Theory
Applied exercises
Laboratory practice: optical instruments

Full-or-part-time: 24h 30m
Theory classes: 5h
Practical classes: 2h 30m
Laboratory classes: 2h
Self study : 15h

3: Interferences and diffraction

Description:
3.1. Electromagnetic wave interference
3.2. Applications: Interferometers, accurate distance measurement, interferometric sensors, optical filters, ...
3.3. Fraunhofer diffraction and resolution limits in optical images
3.4. Applications: Diffraction gratings and spectroscopy, micrometric measurement, interferometric microscopy, X-ray diffraction and crystal analysis, ...
3.5. Fresnel diffraction and holography
3.6. Applications: Holographic storage, holographic interferometry, optical correlation and image recognition

Related activities:
Theory
Applied exercises
Laboratory practices: interferometry and diffraction measurements

Full-or-part-time: 24h 30m
Theory classes: 5h
Practical classes: 2h 30m
Laboratory classes: 2h
Self study : 15h

4: Polarizers and anisotropic media

Description:
4.1. Polarization, dichroism, birefringence and optical activity,
4.2. Applications: Delay plates, polarimetry, photoelasticity, phase contrast microscopy, crystalline optics, ...
4.3. Optical modulators. Electro-optical, acoustic-optical, magneto-optical

Related activities:
Theory
Applied exercises
Laboratory practices: Polarimetry, birrefringence and dichroisme

Full-or-part-time: 24h 30m
Theory classes: 5h
Practical classes: 2h 30m
Laboratory classes: 2h
Self study : 15h

5: Lasers and photoemitters

Description:
5.1. Light emitters.
5.2. Spontaneous emission: Black body radiation, incandescent and discharge lamps, fluorescents, LEDs, synchrotron radiation, ...
5.3. Stimulated emission: The laser. Principles of operation, pumping, optical cavity, characteristics of laser light
5.4. Types of lasers: Solid state, gas, molecular gas, excimer, chemical, dye, semiconductor lasers (EELs, VCSELs), ...

Related activities:
Theory
Applied exercises
Laboratory practices: Spectrometry

Full-or-part-time: 13h 15m
Theory classes: 2h 30m
Practical classes: 1h 15m
Laboratory classes: 2h
Self study : 7h 30m

6: Laser technology

Description:
6.1. Industrial applications of laser: Drilling, cutting, welding, polishing and marking.
6.2. Data: Reading, writing, transmission,
6.3. Measurements (distances, profiles, ...) and images by laser (LIDAR)
6.4. Material characterization, laser spectroscopy, photochemistry, isotopic separation, ...
6.5. Medical applications: Surgery, phototherapy, dentistry, cancer treatment, ...
6.6. Other applications: Telemetry, lithography, nuclear fusion

Related activities:
Theory

Full-or-part-time: 11h 15m
Theory classes: 2h 30m
Practical classes: 1h 15m
Self study : 7h 30m

7: Photodetectors and imaging

Description:
7.1. Thermal photodetectors
7.2. Semiconductor photodetectors: Photoconductors, photodiodes, avalanche photodiodes, phototransistors, ...
7.3. Other photodetects: Photomultipliers (night vision), photochemicals (photographic film), photoelectric cells and photovoltaic cells (solar cells).
7.4. Detector arrays. CCD and CMOS cameras.
7.5. Image detection: Microscopy (optical, fluorescence, two-photon, electronics, OCT, ...). Super resolution microscopy (NORM, STED, SIM, ...)
7.6. Radiometry, photometry and colorimetry

Related activities:
Theory
Laboratory practices
Specific Work

Full-or-part-time: 13h 45m
Theory classes: 2h 30m
Practical classes: 1h 15m
Laboratory classes: 2h 30m
Self study : 7h 30m

8: Wave guides, optical fibers and optical metamaterials

Description:
8.1. Waveguides and fiber optics
8.2. Transport of information and images
8.3. Optical metamaterials: Perfect imaging, invisibility, ...

Related activities:
Theory
Specific work

Full-or-part-time: 13h 45m
Theory classes: 2h 30m
Practical classes: 1h 15m
Laboratory classes: 2h 30m
Self study : 7h 30m

ACTIVITIES

1: Theory

Description:
1.- Nature and propagation of light
1.1 Electromagnetic waves
1.2. Radiation generation and electromagnetic spectrum
1.3. Propagation in dielectric materials, reflection and transmission
1.4. Propagation in non-homogeneous media
1.5. Applications: Laser telemetry, object detection, alignment, data readers, profilometers, detectors of position, speed and rotation

2.- Geometric optics and Optical instruments
2.1. Optical systems and imaging
2.2. Optical instrumentation: Camera, telescope, microscope, confocal microscope, ...
2.3. Prisms and spectroscopy

3.- Interference and diffraction
3.1. Electromagnetic wave interference
3.2. Applications: Interferometers, accurate distance measurement, interferometric sensors, optical filters, ...
3.3. Fraunhofer diffraction and resolution limits in optical images
3.4. Applications: Diffraction gratings and spectroscopy, micrometric measurement, interferometric microscopy, X-ray diffraction and crystal analysis, ...
3.5. Fresnel diffraction and holography
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4.1. Polarization, dichroism, birefringence and optical activity,
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4.3. Optical modulators. Electro-optical, acoustic-optical, magneto-optical

5.- Lasers and photoemitters
5.1. Light emitters.
5.2. Spontaneous emission: Black body radiation, incandescent and discharge lamps, fluorescents, LEDs, synchrotron radiation, ...
5.3. Stimulated emission: The laser. Principles of operation, pumping, optical cavity, characteristics of laser light
5.4. Types of lasers: Solid state, gas, molecular gas, excimer, chemical, dye, semiconductor lasers (EELs, VCSELs), ...

6.- Laser Technology
6.1. Industrial applications of laser: Drilling, cutting, welding, polishing and marking.
6.2. Data: Reading, writing, transmission,
6.3. Measurements (distances, profiles, ...) and images by laser (LIDAR)
6.4. Material characterization, laser spectroscopy, photochemistry, isotopic separation, ...
6.5. Medical applications: Surgery, phototherapy, dentistry, cancer treatment, ...
6.6. Other applications: Telemetry, lithography, nuclear fusion

7.- Photodetectors and imaging
7.1. Thermal photodetectors
7.2. Semiconductor photodetectors: Photoconductors, photodiodes, avalanche photodiodes, phototransistors, ...
7.3. Other photodetects: Photomultipliers (night vision), photochemicals (photographic film), photoelectric cells and photovoltaic cells (solar cells).
7.4. Detector arrays. CCD and CMOS cameras.
7.5. Image detection: Microscopy (optical, fluorescence, two-photon, electronics, OCT, ...). Super resolution microscopy (NORM, STED, SIM, ...)
7.6. Radiometry, photometry and colorimetry

8.- Wave guides, Optical fibres and optical metamaterials
8.1. Waveguides and fiber optics
8.2. Transport of information and images

8.3. Optical metamaterials: Perfect imaging, invisibility, ...

Full-or-part-time: 30h
Theory classes: 30h

2: Applied exercices

Description:
Application exercices of the different topics

Full-or-part-time: 15h
Practical classes: 15h

3: Laboratory

Description:
The practices will be dedicated to applying the knowledge learned in theory classes. Conceptual but also quantitative practices, measurements and treatment of results.
Practices include the following topics: Light propagation, construction of optical systems, polarization and birefringence, interference, diffraction, spectrometry, laser.
Lab sessions are two hours long and are done in teams of two or more people. Teams will rotate, so each team will do a different practice. Professor's explanations and help during the practice. Each team submits a report.

Specific objectives:
Observation and verification in the laboratory of the optical effects explained in the subject.
Measurement of light properties (polarization, wavelength, ...) and their effects (propagation, interference, diffraction, ...)
Optical measurement systems (spectrometry, polarimetry, interferometry, microscopy, ...).
Knowledge of optical devices.

Material:
Practice lab-guides

Delivery:
Each team submits a laboratory report.

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

4: Work on a specific topic 1

Description:
Work on current applications of photonics to engineering and new technologies in the field of photonics. The work will serve to deepen in a subject chosen by the student (of the proposed list or by own interest) related with the topics of the subject. It will be done in groups of 2 or 3 people.
Oral presentation of the work and answering questions. Ask questions in other students' presentations.

Material:
Material and bibliography provided by the professor

Delivery:
Study of a specific topic of interest to the student
Oral presentation of the work. Answer questions. Ask questions in other students' presentations.

Full-or-part-time: 2h 30m
Laboratory classes: 2h 30m

5: Work on a specific topic 2

Description:
Work on current applications of photonics to engineering and new technologies in the field of photonics. The work will serve to deepen in a subject chosen by the student (of the proposed list or by own interest) related with the topics of the subject. It will be done in groups of 2 or 3 people.
Oral presentation of the work and answering questions. Ask questions in other students' presentations.

Material:
Material and bibliography provided by the professor

Delivery:
Study of a specific topic of interest to the student
Oral presentation of the work. Answer questions. Ask questions in other students' presentations.

Full-or-part-time: 2h 30m
Laboratory classes: 2h 30m

self learning

Full-or-part-time: 90h
Self study: 90h

GRADING SYSTEM

- Laboratory: 35%
- Applied exercises: 25%
- 1st work in a specific topic: 20%
- 2nd work in a specific topic: 20%

EXAMINATION RULES.

Laboratory: Visualization and application of the light properties. Work in teams. Guide and professor explanations during the practice. Each team will submit a report.
Specific works: Work in groups of 2 or 3 people. Topic chosen by the students (topics proposed by the professor or of their own interest). Oral presentation.

BIBLIOGRAPHY

Basic:
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- Saleh, B.E.A.; Teich, M.C. Fundamentals of photonics. New York: Wiley-Interscience, 1991. ISBN 0471839655.
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- Pedrotti, Frank L.; Pedrotti, Leno M.; Pedrotti, Leno S. Introduction to optics. 3rd ed [re-issued]. Cambridge: Cambridge University Press, 2018. ISBN 9781108428262.

Complementary:
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- Bachs, L.; Cuesta, J.; Nogués, C. Aplicaciones industriales del láser. Barcelona: Marcombo, 1988. ISBN 842670719X.
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