Course guide
370047 - BIOFOTO - Introduction to Biophotonics

Last modified: 02/07/2024

Unit in charge: Terrassa School of Optics and Optometry
Teaching unit: 731 - OO - Department of Optics and Optometry.

Degree: BACHELOR'S DEGREE IN OPTICS AND OPTOMETRY (Syllabus 2020). (Optional subject).

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** Catalan, English

LECTURER

Coordinating lecturer: Vilaseca Ricart, Meritxell (http://futur.upc.edu/MeritxellVilasecaRicart)

Others: Royo Royo, Santiago (http://futur.upc.edu/SantiagoRoyoRoyo)
Pujol Ramo, Jaume (https://futur.upc.edu/JaumePujolRamo)

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
CT6. Independent learning. Identify and overcome gaps in one's knowledge by thinking critically and choosing the best approach to extending one's knowledge.
CT7. Foreign language. Demonstrate knowledge of a foreign language, preferably English, at an oral and written level that is consistent with graduates' future needs.

CT3. Teamwork. To be able to work as a member of a multidisciplinary team, either as a base member or undertaking managerial decisions aiming at developing projects from a practical and responsible standpoint, adopting commitments given the available resources
CT5. Efficient use of informacion resources. To manage data and technical and scientific information adquisition, organization, analysis and visualization and to provide a critical appraisal of the results of this management

Basic:
CB2-OPT. (ENG) Que los estudiantes sepan aplicar sus conocimientos a su trabajo o vocación de una forma profesional y osean las competencias que suelen demostrarse por medio de la elaboración y defensa de argumentos y la resolución de problemas dentro de su área de estudio
CB3-OPT. (ENG) Que los estudiantes tengan la capacidad de reunir e interpretar datos relevantes (normalmente dentro de su área de estudio) para emitir juicios que incluyan una reflexión sobre temas relevantes de índole social, científica o ética

TEACHING METHODOLOGY

Lectures and problem solving classes
Activities:
- Laboratory/Research center visits
- Lab skills with photonic instrumentation
- Seminars
The student will have the possibility of performing measurements using experimental setups and commercial instruments.

LEARNING OBJECTIVES OF THE SUBJECT

Many governments of industrialized countries have recognized the great potential of biophotonics as a key technology with the aim of developing innovative light-based systems that can be transferred to medical practice seeking to understand and treat diseases. Consequently, the use of photonic tools is becoming common practice in various fields of medicine, for example, in areas such as visual health or cancer.
First of all, the objective of this subject is to describe the fundamentals of photonics: what light is, how it is detected from sensors and cameras, how it is generated from light sources and screens, and how it can be modulated using optical devices. Light-matter interaction and, in particular, the optics of biological tissue (propagation and scattering of light in human tissues) will also be analysed.
Finally, all currently existing photonic treatment (laser) and diagnostic tools used in the field of biomedicine and, in particular, ophthalmology and optometry will be studied. Examples of light treatments are hair removal or laser scalpels and, in the field of ophthalmology and optometry, photocoagulation in diabetic retinopathy, laser refractive surgery, laser photoemulsification in cataract surgery, or new treatments using lasers with ultrashort pulses such as SMILE surgery, among others. Examples of innovative diagnostic systems are OCT, laser scanning ophthalmoscopy or spectroscopy.

STUDY LOAD

Type	Hours	Percentage
Self study	45,0	60.00
Hours small group	7,5	10.00
Hours medium group	22,5	30.00

Total learning time: 75 h

CONTENTS

FUNDAMENTALS OF PHOTONICS

Description:
Light. Spatial and spectral measurements and color features (2h)
Light generation. Light sources, types and applications of LED and laser systems (1h)
Displaying and detecting light. Sensors and cameras, displays and screens (2h)
Light modulation. Liquid crystal displays and deformable mirrors (1h)
Light-matter interaction and light propagation (2h)
Tissue optics: absorption and scattering coefficients (1h)

Full-or-part-time: 23h
Practical classes: 9h
Self study : 14h

BIOMEDICAL PHOTONICS

Description:
Photonic tools for laser therapy:
- Thermal effects (retinal photocoagulation for diabetic retinopathy, retinal detachment, tumors, hair removal, laser scalpels, ...) (2h)
- Photoablation (laser refractive surgery PRK, LASIK, LASEK,...) (2h)
- Mechanical effects: plasma and photodisruption (posterior capsulotomy, laser phacoemulsification, laser corneal flap corneal, new procedures for refractive surgery baser on ultra-short lasers SMILE, ...) (2h)
- Chemical effects (photodynamic therapy for cancer treatment) (2h)

Photonic tools for diagnosis:
- Imaging techniques of the anterior segment and the retina (Scheimpflug camera, laser scanning ophthalmoscopy, SLO, and optical coherence tomography, OCT) (2h)
- Reflectance, fluorescence and Raman spectroscopy (2h)
- Aberrometry and double pass technique for the evaluation of the optical quality of the eye (1h)
- Pulse oximetry, vein viewers and photoacoustic imaging (2h)

Full-or-part-time: 35h
Practical classes: 15h
Self study : 20h

ACTIVITIES

APPLICACIONS AND RESEARCH IN THE FIELDS OF OPTICAL ENGINEERING AND BIOPHOTONICS

Description:
Laboratory skills and guided research center visits where applications related with the following áreas will be seen: optical metrology, visual optics, spectroscopy, color technology and spectral imaging science.

Students will have the possibility of performing measurements using experimental setups and commercial instruments.

Full-or-part-time: 6h
Laboratory classes: 6h

GRADING SYSTEM

- Homework assessments (40%)
- Written exam (50%)
- Practical skills (10%)

To access the reevaluation of the subject, it will be necessary to comply with the general conditions established each year by the Academic Regulations for Degree and Master's Studies of the UPC (NAGRAMA) and those of the FOOT (having obtained a final grade of the subject equal to or greater than 3). Students who pass the revaluation exam will have a final grade of 5 in the subject. Otherwise, the highest qualification between the one obtained in the previous evaluation and that of the reevaluation will be maintained.
Individual test lasting two hours. The test consists of a theoretical part where questions relating to theoretical concepts of the content given in class are formulated and a practical part, where several problems and/or questions must be solved.
Material: Theory notes and problems available through the ATENEA virtual campus and recommended bibliography.
Statements, calculator and form.
Deliverable: Resolution of the test. It represents 100% of the final grade of the subject.

BIBLIOGRAPHY

Basic:
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- Liu, Jia-Ming. Photonic devices. Cambridge: Cambridge University Press, cop. 2005. ISBN 9780521551953.
- Berns, Roy S; Billmeyer, Fred W.; Saltzman, Max. Billmeyer and Saltzman's Principles of color technology. 3rd ed. New york, [etc.]: John Wiley & Sons, cop. 2000. ISBN 047119459X.
- Prasad, Paras N. Introduction to biophotonics. Hoboken, New Jersey: John Wiley & Sons, cop. 2003. ISBN 0471287709.
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- Vo-Dinh, Tuan. Biomedical photonics handbook. 2nd ed. Boca Raton, Fla: CRC Press, 2015-. ISBN 9781439804445.
- Berlien H. P; Müller, Gerhard J. Applied laser medicine. Berlin [etc.]: Springer, cop. 2003. ISBN 9783540670056.

Complementary:
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- Chigrinov, Vladimir G. Liquid crystal devices: physics and applications. Boston [etc.]: Artech House, cop. 1999. ISBN 0890068984.
- Porter, Jason. Adaptive optics for vision science: principles, practices, design, and applications. Hoboken, NJ: Wiley-Interscience, cop. 2006. ISBN 9780471679417.
- Grahn, Hans; Geladi, Paul. Techniques and applications of hyperspectral image analysis [on line]. West Sussex: John Wiley, cop. 2007 [Consultation: 30/01/2023]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9780470010884. ISBN 9780470010860.
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