ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000983 - Biophotonics

DEGREE PROGRAMME

09AU - Master Universitario En Ingenieria Biomedica

ACADEMIC YEAR & SEMESTER

2023/24 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93000983 - Biophotonics
No of credits	3 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	09AU - Master Universitario en Ingenieria Biomedica
Centre	09 - Escuela Tecnica Superior De Ingenieros De Telecomunicacion
Academic year	2023-24

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Paloma Rodriguez Horche	B-117	p.rhorche@upm.es	Sin horario. At any time, by making an appointment
Antonio Perez Serrano (Subject coordinator)	B-101	antonio.perez.serrano@upm.es	Sin horario. At any time, by making an appointment

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Electronics Fundamentals

- Optics Fundamentals

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

CB07 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio

CB08 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CB09 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CG-MIB05 - Utilizar técnicas de expresión oral y escrita para comunicar trabajos y conclusiones a comunidades de iguales o divulgación científica, elaboración de artículos, manuales de estilo y herramientas de edición para fomentar la capacidad de comunicación y diseminación de resultados

CG-MIB07 - Utilizar la lengua inglesa como herramienta de trabajo

4.2. Learning outcomes

RA34 - Aplicar los principios y aplicaciones de los campos bioeléctricos, desde una descripción de los aspectos básicos de los tejidos excitables causantes de la actividad bioelectromagnética y de su fundamento teórico y formalización matemática. Derivación de los fenómenos bioelectromagnéticos para el análisis e interpretación de las variables medidas. Estudiar las aplicaciones clínicas de los campos electromagnéticos

RA35 - Aplicar los fenómenos relacionados con la interacción de radiaciones láser con los tejidos orgánicos, para el diseño de instrumentación médica basada en técnicas fotónicas y los dispositivos de captación de señales mediante las mismas.

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

Biophotonics, often called biomedical optics, is generally conceived to bear a fundamental concept: to understand and manipulate how light interacts with biological matter. From a global viewpoint, biophotonics refers to the detection, reflection, emission, modification, absorption, creation, and manipulation of photons as they interact with biological cells, organisms, molecules, tissues, substances and even whole organisms.Biophotonics has become an indispensable tool for basic life sciences research and for biomedical diagnosis, therapy, monitoring, imaging, and surgery.

This course is an introduction to the fundamentals of Biophotonics and its instrumentation associated with the phenomena related to the generation of coherent light, transmission by optical components such as lenses and optical fibers, modulation and detection of light. The different theories of light will be reviewed, including optical rays and waves, and concepts such as scattering, interference and diffraction will be studied. These concepts will allow a deeper understanding of the physical foundations on which most of the applications of Biophotonics are based.

This course will consist mainly in the development of a project, but it will contain theoretical sessions and laboratory

sessions. Therefore, the course is a project-based course that introduces the student to Biophotonics. After introductory theoretical and lab sessions, the students will develop a project. This project will be proposed by the professors or by the student, and it will be scientifically oriented, including different topics about biophotonics and electronics, by means of low-cost and open hardware platforms such as Arduino. The theoretical part of the course is detailed in the next section, and the lab sessions in the following:

Laboratory Sessions:

Lab session 1: Absorbance experiments
- Measuring absorbance of a specific solution.
- To determine from Beer's law, the characteristic absorption coefficient of a water/colorant solution.

Lab session 2: Pulse-oximetry
- Principle of pulse and blood oxygen measurement
- Measurement and signal processing for pulse and blood oxygen concentration acquisition using a LabVIEW-based acquisition system.

5.2. Syllabus

1. Introduction to Biophotonics
    1.1. What is biophotonics?
    1.2. Applications
    1.3. Spectral Windows in biophotonics
2. Fundamental Principles of Photonics
    2.1. Geometrical Optics
    2.2. Wave Optics
    2.3. Electromagnetic Optics
    2.4. Quantum Optics
    2.5. Radiation-matter interaction
3. Basic Biophotonic Instrumentation
    3.1. Light sources: lasers and LEDs
    3.2. Light detectors
    3.3. Waveguides and optical fibers
4. Interaction of light with biological material and tissues
    4.1. Light transport in tissue
    4.2. Photochemical interaction
    4.3. Thermal interaction
    4.4. Photoablation
    4.5. Photodisruption

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**Course presentation and Chapter 1: Introduction to biophotonics.** Duration: 02:00 Lecture			
2	**Chapter 2: Fundamental principles of photonics** Duration: 02:00 Lecture			
3	**Chapter 2: Fundamental principles of photonics** Duration: 02:00 Lecture			
4	**Chapter 2: Fundamental principles of photonics** Duration: 02:00 Lecture			**Project First Report** Group work Continuous assessment and final examination Not Presential Duration: 00:00
5	**Chapter 3: Basic biophotonics instrumentation** Duration: 02:00 Lecture			
6	**Chapter 3: Basic biophotonics instrumentation** Duration: 02:00 Lecture			
7		**Project Development** Duration: 02:00 Laboratory assignments		
8	**Chapter 4: Interaction of light with biological material and tissues** Duration: 02:00 Lecture			**Project Second Report** Group work Continuous assessment and final examination Not Presential Duration: 00:00
9	**Chapter 4: Interaction of light with biological material and tissues** Duration: 02:00 Lecture			
10		**Lab session 1** Duration: 02:00 Laboratory assignments		

11		**Lab session 2** Duration: 02:00 Laboratory assignments		
12		**Project Development** Duration: 02:00 Laboratory assignments		**Lab Report** Group work Continuous assessment and final examination Not Presential Duration: 00:00
13		**Project Development** Duration: 02:00 Laboratory assignments		
14		**Project Development** Duration: 02:00 Laboratory assignments		
15		**Project Development** Duration: 02:00 Laboratory assignments		
16				**Project Presentation** Group presentation Continuous assessment and final examination Presential Duration: 02:00 **Project Final Report** Group work Continuous assessment and final examination Not Presential Duration: 00:00
17				

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
4	Project First Report	Group work	No Presential	00:00	5%	0 / 10	CB06 CB07 CB08 CG-MIB05
8	Project Second Report	Group work	No Presential	00:00	5%	0 / 10	CB06 CB07 CB08 CG-MIB05
12	Lab Report	Group work	No Presential	00:00	10%	0 / 10	CB06 CB07 CB08 CG-MIB05
16	Project Presentation	Group presentation	Face-to-face	02:00	40%	0 / 10	CB06 CB07 CB09 CB08 CB10 CG-MIB05 CG-MIB07
16	Project Final Report	Group work	No Presential	00:00	40%	0 / 10	CB06 CB07 CB09 CB08 CB10 CG-MIB05

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
4	Project First Report	Group work	No Presential	00:00	5%	0 / 10	CB06 CB07 CB08 CG-MIB05

8	Project Second Report	Group work	No Presential	00:00	5%	0 / 10	CB06 CB07 CB08 CG-MIB05
12	Lab Report	Group work	No Presential	00:00	10%	0 / 10	CB06 CB07 CB08 CG-MIB05
16	Project Presentation	Group presentation	Face-to-face	02:00	40%	0 / 10	CB06 CB07 CB09 CB08 CB10 CG-MIB05 CG-MIB07
16	Project Final Report	Group work	No Presential	00:00	40%	0 / 10	CB06 CB07 CB09 CB08 CB10 CG-MIB05

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Individual Project Report	Individual work	Face-to-face	00:00	50%	0 / 10	CB06 CB07 CB09 CB08 CB10 CG-MIB05
Individual Project Presentation	Individual presentation	Face-to-face	02:00	50%	0 / 10	CB06 CB07 CB09 CB08 CB10 CG-MIB05 CG-MIB07

7.2. Assessment criteria

The final grade will be given by several marks: deliveries related to the project (50%), presentation of the project (40%) and completion of the lab sessions and delivery of their respective reports (10%). Regarding the documentation submitted, the content and the sources on which the students have based their work will be assessed, as well as the presentation of the document and its organization. Regarding the presentation, its contents and the way they are presented will be assessed. A good structure and organization of the presentation will be valued, as well as the use of technical language and the ability to summarize the conclusions. It will also be taken into account that speakers use the time available for their presentation appropriately and do not exceed it.
Students will be qualified through progressive evaluation by default. According to the Normativa de Evaluación del Aprendizaje de la Universidad Politécnica de Madrid, students will have two additional opportunities to pass the course: global evaluation and extraordinary evaluation. Global evaluation will allow the students to pass or improve the grades of the complete course or some of the parts of the progressive evaluation. A student recurring to the extraordinary evaluation will be evaluated again of the complete course. Lab sessions are a mandatory activity, the Lab report will be evaluated independently to the evaluation mode.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Course documents	Web resource	Slides and other documentation available in Moodle
Laboratory Guide	Others	Laboratory manual
Biophotonic Lab	Equipment	Lab Brigathier Mathé of the Departamento de Tecnología Fotónica y Bioingeniería.
Gerd Keiser. Biophotonics, Concepts to Applications. Springer 2016.	Bibliography	Basic bibliography

Biomedical Photonics Handbook, Second Edition. Editado por Tuan Vo-Dinh. CRC Press. 2014	Bibliography	Basic bibliography
David A. Boas, Constantinos Pitris, Nimmi Ramanujam. Handbook of Biomedical Optics. CRC Press. 2011	Bibliography	Complementary bibliography
Jeong-Yeol Yoon. Introduction to Biosensors: From Electric Circuits to Immunosensors. Springer Science+Business Media New York 2013	Bibliography	Complementary bibliography
Shuichi Kinoshita. Bionanophotonics: An Introductory Textbook. Pan Stanford 2013	Bibliography	Complementary bibliography

9. Other information

9.1. Other information about the subject

The course Biophotonics contributes to the Sustainable Development Goals (SDA) of the United Nations Agenda 2030 in different ways. On the one hand, it contributes to Objective 3: Health and Well-being, since the techniques and devices studied in the course are used in the prevention and treatment of different diseases and injuries. In particular, it is related to SDA3, objectives 3.1, 3.2, 3.8, 3.9 and 3.d. On the other hand, the experimental part of the course consists of the design and practical realization of electronic circuits with biophotonic devices based on open source platforms and hardware, and students are encouraged to publish their results following this philosophy. For this reason, the course contributes to SDA Objective 4: Education and its sub-objectives 4.4 and 4.7 by improving professional and technical skills and instilling in students the development and sharing of knowledge to promote sustainable development. The publication of results on open platforms helps to increase access to ICTs in LDCs which is directly related to SDA9, objectives 9.a, 9.b and 9.c, and SDA17, objectives 17.6 and 17.7.