ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

43000618 - Materiales Para Disopsitivos FotÓnicos

DEGREE PROGRAMME

04AN - Master Universitario En Ingenieria De Materiales

ACADEMIC YEAR & SEMESTER

2023/24 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	43000618 - Materiales para Disopsitivos Fotónicos
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	04AN - Master Universitario en Ingenieria de Materiales
Centre	04 - Escuela Tecnica Superior De Ingenieros De Caminos, Canales Y Puertos
Academic year	2023-24

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Morten Andreas Geday (Subject coordinator)	B321	morten.geday@upm.es	M - 11:00 - 12:00 Tutorial upon previous request by email
Patxi Xabier Quintana Arregui	B321	x.quintana@upm.es	W - 11:00 - 12:00 Tutorials upon previous request by email

Clara Quevedo Galan	B101	clara.quevedo.galan@upm.es	M - 11:00 - 11:15 Tutoring upon previous request by email

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

3. Skills and learning outcomes *

3.1. 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.

CE1 - Capacidad para aplicar los fundamentos científicos del comportamiento físico y químico de los materiales para relacionar causalmente sus propiedades fundamentales físicas y químicas con su comportamiento macroscópico y el de los productos con ellos realizados / Ability to apply the scientific foundations of the physical and chemical behavior of materials to correlate their fundamental physical and chemical properties with their macroscopic behavior and that of the products made with them.

CE2 - Uso de equipos y técnicas experimentales de caracterización de materiales (micro y macroestructura, comportamientos mecánico, eléctrico, y óptico) para identificar y analizar los diversos tipos de materiales / Use of equipment and experimental techniques for the characterization of materials (micro and macrostructure, mechanical, electrical, and optical behavior) to identify and analyze the various types of materials.

CE4 - Autonomía para adquirir, analizar, actualizar y aplicar nuevos conocimientos, modelos y técnicas experimentales y numéricas en relación con la composición y estructura de los materiales, su caracterización física y química, sus procesos de fabricación, su utilización y aplicación científica y tecnológica, y su reciclado, reutilización y eliminación / Autonomy to acquire, analyze, update and apply new knowledge, models and experimental and numerical techniques related to the composition and structure of materials, their physical and chemical characterization, their manufacturing processes, their use and scientific and technological application, and their recycling, reuse and disposal

CE8 - Aplicación del método científico para la resolución de problemas y la generación de conocimiento / Application of the scientific method to solve problems and generate knowledge

CE9 - Capacidad de realizar un trabajo o proyecto individual integrando y relacionando las competencias adquiridas en las distintas asignaturas del máster, junto con la capacidad de defenderlo en público ante un tribunal universitario experto en el tema del trabajo / Ability to carry out an individual job or project integrating and relating the skills acquired in the different subjects of the master's degree, together with the ability to defend it in public before an expert university panel on the topic of the job

CG1 - Uso de la lengua inglesa: Los alumnos son capaces de transmitir conocimientos y expresar ideas y argumentos de manera clara, rigurosa y convincente, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia / Use of the English Language: Students are able to transmit knowledge and express ideas and arguments in a clear, rigorous and convincing manner, both orally and in writing, adapting to the characteristics of the situation and the audience .

CG2 - Liderazgo: Los estudiantes son capaces de dirigir y coordinar personas para que trabajen con entusiasmo en la consecución de objetivos en pro del bien común / Leadership: Students are capable of directing and coordinating people so that they work enthusiastically to achieve objectives for the common good.

CG3 - Trabajo en equipo: Los alumnos desarrollan la capacidad para trabajar en equipo, integrarse y colaborar de forma activa en la consecución de objetivos comunes / Teamwork: Students develop the ability to work as a team,

integrate and actively collaborate in achieving common goals.

CG4 - Creatividad: Los alumnos son capaces de resolver de forma nueva, original y aportando valor, situaciones o problemas en el ámbito de la ingeniería de materiales / Creativity: Students are able to solve situations or problems in the field of materials engineering in a new, original way and adding value.

CG9 - Análisis y Síntesis: Los alumnos son capaces de reconocer y describir los elementos constitutivos de una realidad, y de proceder a organizar la información significativa según criterios preestablecidos adecuados a un propósito / Analysis and Synthesis: Students are able to recognize and describe the constituent elements of a reality, and to proceed to organize significant information according to pre-established criteria suitable for a purpose.

3.2. Learning outcomes

RA2 - Ser capaz de aprender y actualizar autónomamente nuevos conocimientos y técnicas

RA4 - 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

RA8 - RA32 - Conocer, comprender y saber aplicar los fundamentos científicos del comportamiento de los materiales

RA7 - RA53 - Ser creativo, ejecutando el trabajo con responsabilidad y respeto a los demás

RA1 - Saber comunicar conocimientos, procedimientos, resultados o técnicas relacionadas con el comportamiento y el uso de materiales

RA3 - Conocer, comprender y saber aplicar las bases de la ciencia y del método científico

RA5 - 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

RA9 - RA17 - Conocimiento aplicado del funcionamiento de los dispositivos de semiconductores sobre los que se desarrolla la optoelectrónica actual, y de la elección y tecnología de materiales necesarios para cumplir las especificaciones requeridas en aplicaciones comerciales

* 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.

4. Brief description of the subject and syllabus

4.1. Brief description of the subject

The scope of this course is that students understand a number of fundamental techniques and procedures relevant to the creation, handling, transmission, modification, and detection of light and the specific functional materials employed in photonic devices. Students will learn the physical fundamentals of the different measurement techniques and the most relevant characterization procedures both, from the theoretical and practical point of view, including the requirements for the material and device to accomplish their application in real scenarios. By the end of the course, students should be able to analyze and evaluate the results, and to design alternative setups selecting materials and characterization techniques

4.2. Syllabus

1. Theory session 1 (90 min): Presentation of the course
    1.1. Absorption, spontaneous emission, stimulated emission, spectra of atoms and molecules
    1.2. Basic structure and absorption in optical fibre
    1.3. Fabry-Pérot (FP) interferometers and cavities
    1.4. Fibre Bragg Grating (FBG)
2. Theory session 2 (90 min): Emitters
    2.1. General features of emitters i.e. LED and lasers
    2.2. Laser diodes (LDs) (Gain, modes, losses)
3. Laboratory session 0 (180 min): P0: Introduction to the laboratory
    3.1. Current and Optical Power response of LEDs and a Laser Diodes (LD)
    3.2. Threshold current and characteristic temperature of a LD
    3.3. Attenuation of an optical fiber
4. Theory session 3 (90 min): Optical Components I
    4.1. Single mode waveguides (introduction)
    4.2. Power splitter (single mode and multimode)
    4.3. Wavelength division multiplexor
5. Theory session 4 (90 min): Optical Components II

5.1. Birefringence and Faraday effect

5.2. Circulator, isolator

5.3. EDFAs and Fibre lasers

6. Theory session 5 (90 min): Optical Detection

6.1. PIN receiver

6.2. Optical spectral analyser

7. Laboratory sessions 1-4 (4x180 min) -Not necessarily sequential

7.1. P1: OSA I:

7.1.1. LED and Laser diode emission spectra

7.1.2. WDM and Optical fibre transmission spectra

7.2. P2: OSA II

7.2.1. EDFA ASE spectra

7.2.2. FBG transmission and reflection spectra

7.2.3. Fibre laser spectra

7.3. P3: Components

7.3.1. 2x2 Flat spectrum coupler Characterisation

7.3.2. WDM Characterisation

7.3.3. 3-way circulator Characterisation

7.4. P4: PIN receiver

7.4.1. Current-Voltage (I-V) of a silicon photodiode

7.4.2. Characterisation of a simple PIN receptor circuit

8. Theory session 6 (90 min): Optical fibre and waveguides

8.1. Optical waveguiding and modes

8.2. Temporal dispersion in optical fibre

9. Laboratory sessions 5-6 (2x180 min) -Not necessarily sequential

9.1. P5: Optical Time Domain Reflectometer

9.1.1. OTDR characterisation

9.1.2. Fibre link characterisation

9.1.3. Optical fibre splicing

9.2. P6: Optical Fibre

9.2.1. Speed of light in fibre

9.2.2. Optical fibre temporal dispersion

5. Schedule

5.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**Presentation of the course. Absorption, spontaneous emission, stimulated emission, spectra of atoms and molecules Basic structure and absorption in optical fibre Fabry-Pérot (FP) interferometers and cavities. Fibre Bragg Grating (FBG)** Duration: 01:30			
2	**Emitters General features of emitters i.e. LED and lasers. Laser diodes (LDs) (Gain, modes, losses)** Duration: 01:30			
3		**P0: Introduction to the laboratory Current and Optical Power response of LEDs and a Laser Diodes (LD) Threshold current and characteristic temperature of a LD. Attenuation of an optical fiber** Duration: 03:00		**Test prior to execution of laboratory** Continuous assessment Presential Duration: 00:10
4	**Optical Components I Single mode waveguides (introduction) Power splitter (single mode and multimode) Wavelength division multiplexor** Duration: 01:30			**Report on previous weeks laboratory session** Continuous assessment Not Presential Duration: 01:00
5	**Optical Components II Birefringence and Faraday effect Circulator, isolator EDFAs and Fibre lasers** Duration: 01:30			
6	**Optical Detection PIN receiver Optical spectral analyser** Duration: 01:30			
7		**P1: OSA I: LED and Laser diode emission spectra. WDM and Optical fibre transmission spectra** Duration: 03:00		**Test prior to execution of laboratory** Continuous assessment Presential Duration: 00:10
8		**P2: OSA II: EDFA ASE spectra FBG transmission and reflection spectra Fiber laser spectra** Duration: 03:00		**Report on previous weeks laboratory session** Continuous assessment Not Presential Duration: 01:00 **Test prior to execution of laboratory**

				Continuous assessment Presential Duration: 00:10
9		**P3: Components: 2x2 Flat spectrum coupler Characterisation WDM Characterisation 3-way circulator Characterisation** Duration: 03:00		**Report on previous weeks laboratory session** Continuous assessment Not Presential Duration: 01:00 **Test prior to execution of laboratory** Continuous assessment Presential Duration: 00:10
10		**P4: PIN receiver: Current-Voltage (I-V) of a silicon photodiode Characterisation of a simple PIN receptor** Duration: 03:00		**Report on previous weeks laboratory session** Continuous assessment Not Presential Duration: 01:00 **Test prior to execution of laboratory** Continuous assessment Presential Duration: 00:10
11	**Optical fibre and waveguides Optical waveguiding and modes Temporal dispersion in optical fibre** Duration: 01:30			**Report on previous weeks laboratory session** Continuous assessment Not Presential Duration: 01:00
12		**P5: Optical Time Domain Reflectometer: OTDR characterisation Fibre link characterisation Optical fibre splicing** Duration: 03:00		**Test prior to execution of laboratory** Continuous assessment Presential Duration: 00:10
13		**P6: Optical Fibre: Speed of light in fibre Optical fibre temporal dispersion** Duration: 03:00		**Report on previous weeks laboratory session** Continuous assessment Not Presential Duration: 01:00 **Test prior to execution of laboratory** Continuous assessment Presential Duration: 00:10
14	**Review of learnt concepts, recovery of lost session** Duration: 03:00			**Report on previous weeks laboratory session** Continuous assessment Not Presential Duration: 01:00

15				
16				
17				**Final Exam** Final examination Presential Duration: 02:00

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.

6. Activities and assessment criteria

6.1. Assessment activities

6.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	Test prior to execution of laboratory		Face-to-face	00:10	5%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG4 CG9 CE1 CE2 CE4 CE8 CE9
4	Report on previous weeks laboratory session		No Presential	01:00	5%	4 / 10	CB06 CB07 CB09 CB10 CG1 CG2 CG3 CG4 CG9 CE1 CE2 CE4 CE8
7	Test prior to execution of laboratory		Face-to-face	00:10	5%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG4 CG9 CE1 CE2 CE4 CE8 CE9

8	Report on previous weeks laboratory session		No Presential	01:00	10%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG2 CG3 CG4 CG9 CE1 CE2 CE4 CE8
8	Test prior to execution of laboratory		Face-to-face	00:10	5%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG4 CG9 CE1 CE2 CE4 CE8 CE9
9	Report on previous weeks laboratory session		No Presential	01:00	10%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG2 CG3 CG4 CG9 CE1 CE2 CE4 CE8
9	Test prior to execution of laboratory		Face-to-face	00:10	5%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG4 CG9 CE1 CE2 CE4 CE8

							CE9
10	Report on previous weeks laboratory session		No Presential	01:00	10%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG2 CG3 CG4 CG9 CE1 CE2 CE4 CE8
10	Test prior to execution of laboratory		Face-to-face	00:10	5%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG4 CG9 CE1 CE2 CE4 CE8 CE9
11	Report on previous weeks laboratory session		No Presential	01:00	10%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG2 CG3 CG4 CG9 CE1 CE2 CE4 CE8
12	Test prior to execution of laboratory		Face-to-face	00:10	5%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG4 CG9 CE1 CE2 CE4

							CE8 CE9
13	Report on previous weeks laboratory session		No Presential	01:00	10%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG2 CG3 CG4 CG9 CE1 CE2 CE4 CE8
13	Test prior to execution of laboratory		Face-to-face	00:10	5%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG4 CG9 CE1 CE2 CE4 CE8 CE9
14	Report on previous weeks laboratory session		No Presential	01:00	10%	4 / 10	CB06 CB07 CB08 CB09 CB10 CG1 CG2 CG3 CG4 CG9 CE1 CE2 CE4 CE8

6.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills

17	Final Exam		Face-to-face	02:00	100%	5 / 10	CB06 CB07 CB09 CB10 CG1 CG2 CG3 CG4 CG9 CE1 CE2 CE4 CE8 CE9

6.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

6.2. Assessment criteria

This course is centered on the student learning in the laboratory, and hence the progressive evaluation, which require the attendance in each laboratory class is the preferred option.

The progressive evaluation is weighed between short questionnaires (65%) prior to the execution of the laboratory session, and the subsequent report (35%).

However, students with sufficient skills and knowledge not to need attending the individual laboratory sessions, may present themselves for the global, and/or extraordinary exams, without having participated in all laboratory

sessions nor having elaborated the corresponding reports.

The global exam will consist of the student executing a sub-sections of the 7 laboratory session, explaining to the teacher (which will interact as an ill prepared companion) all the necessary steps, and the learning implicit therein. It is the intention that the student during the examination demonstrates the listed skills and learning outcomes, hereunder the skill of explaining themself and the skill of leadership in working groups.

The extraordinary exam will employ the same evaluation scheme as the global exam.

In all evaluations, the skill to express concisely the acquired knowledge in the form of reports and problem solving is crucial.

7. Teaching resources

7.1. Teaching resources for the subject

Name	Type	Notes
Lecture notes	Others	Both the transparencies and the accompanying lecture notes will be shared with the students
Laboratory Access	Equipment	The students will get access to the optical communications laboratory at Teleco, for completion of the laboratory sessions.
Scientfic laboratory access	Equipment	The students will have access to the scientific laboratory for the access to specific instrumentation
HARNESSING LIGHT: SOME NOTES ON PHOTONICS	Bibliography	J.M. OTÓN & E. ÓTON: "HARNESSING LIGHT: SOME NOTES ON PHOTONICS" Book providing all the neccesary knowledge for this course. It is free to read from an UPM address, or may be purchased

Optics	Bibliography	Eugene Hecht, Addison-Wesley, 1990
Light Measurement Handbook	Bibliography	Alex Ryer, "Light Measurement Handbook", Available for free online at various places http://apps.usd.edu/coglab/schieber/pdf/handbook.pdf (Accesed 29/06/2020)
Fundamentals of Photonics	Bibliography	Bahaa E. A. Saleh & Malvin Carl Teich, "Fundamentals of Photonics" John Wiley & Sons, 1991