ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

43000619 - NanoelectrÓnica

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	43000619 - Nanoelectrónica
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 *
Fernando Calle Gomez (Subject coordinator)	Lecture room	fernando.calle@upm.es	Sin horario. After the lectures, in the lecture-room. Otherwise, after specific appointment in the teacher¿s office, ETSIT C-225

Jorge Pedros Ayala		j.pedros@upm.es	Sin horario. After the lectures, in the lecture-room. Otherwise, after specific appointment in the teacher¿s office, ETSIT C-308

* 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

- Advanced Manufacturing Of Functional Materials

3.2. Other recommended learning outcomes

- All obligatory modules in the first quarter, and most modules of the itinerary/route of Functional Materials

- Oral and written English

4. Skills and learning outcomes *

4.1. Skills to be learned

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

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.

CE7 - Manejo de herramientas de simulación numérica para diseño y análisis de materiales, desde la escala microscópica a la macroscópica / Management of numerical simulation tools for design and analysis of materials, from the microscopic to the macroscopic scale

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 .

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.

CG5 - Organización y planificación: Los estudiantes son capaces de fijar objetivos, con la planificación y programación de actividades (tiempo y fases) y con la organización y gestión de los recursos necesarios para alcanzarlos / Organization and Planning: Students are capable of setting objectives, with the planning and programming of activities (time and phases) and with the organization and management of the necessary resources to achieve them..

CG9 - 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

4.2. Learning outcomes

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

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

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

RA11 - knowledge of the basic fabrication methods, structure and properties of nanomaterials and other forms of nanostructured hybrids

* 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

The students should achieve advanced knowledge on materials, structures and devices used in nanotechnology, especially in nanoelectronics and micro/nanosystems, for applications in sensors and actuators used in information technology and communications, bioengineering, etc.

A cooperative and participative methodology will be used.

5.2. Syllabus

1. INTRODUCTION TO NANOELECTRONICS
   1.1. History, role and impact of nanotechnology and nanoelectronics
2. NANOMATERIALS AND NANOTECHNIQUES
   2.1. Materials: semiconductors, C-based structures, 2D
   2.2. Processing and characterization techniques
   2.3. From MEMS to NEMS
3. NANODEVICES
   3.1. Introduction to the MOSFET
   3.2. MOSFET Scaling and Short Channel Effects
4. WORKSHOP ON NANOTECHNOLOGY: Oral presentations by students and debates

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**History, role and impact of nanotechnology and nanoelectronics** Duration: 04:00 Lecture			
2	**Materials: semiconductors, C-based structures, 2D** Duration: 04:00 Lecture			
3	**Processing and characterization techniques** Duration: 04:00 Lecture			
4	**From MEMS to NEMS** Duration: 04:00 Lecture			
5	**Introduction to the MOSFET** Duration: 04:00 Lecture			
6	**MOSFET scaling and short-channel effects** Duration: 04:00 Lecture			
7	**Workshop on Nanoelectronics (1,2)** Duration: 04:00 Cooperative activities			**Paper, presentation and monitoring of team works Compulsory, non-recuperable activity** Group presentation Continuous assessment and final examination Presential Duration: 06:00
8	**Workshop on Nanoelectronics (3)** Duration: 02:00 Cooperative activities			**Exam on nanodevices and scaling** Written test Continuous assessment and final examination Presential Duration: 02:00
9				
10				
11				
12				
13				

14				
15				
16				
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
7	Paper, presentation and monitoring of team works Compulsory, non-recuperable activity	Group presentation	Face-to-face	06:00	70%	5 / 10	
8	Exam on nanodevices and scaling	Written test	Face-to-face	02:00	30%	3 / 10	CB09 CG9 CG1 CE1 CE7

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
7	Paper, presentation and monitoring of team works Compulsory, non-recuperable activity	Group presentation	Face-to-face	06:00	70%	5 / 10	
8	Exam on nanodevices and scaling	Written test	Face-to-face	02:00	30%	3 / 10	CB09 CG9 CG1 CE1 CE7

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Paper, presentation and monitoring of team works Compulsory, non-recuperable activity	Group presentation	Face-to-face	06:00	70%	5 / 10	CB09 CG9 CG1 CG3 CG5 CE1

Exam on nanodevices and scaling	Written test	Face-to-face	02:00	30%	3 / 10	CB09 CG9 CG1 CG5 CE1 CE7

7.2. Assessment criteria

Continuous and global call

Student participation will include assistance to lectures and to discussion sessions afterwards. The progress of the students will be monitored through a 2-3 student team work (70%) and an individual exam (30%).

The team work consists of a paper on a specific topic suggested or approved by the professor (20%), and will be presented in a workshop (40%). During this process, each team will also monitor the other presentations (10%). This activity is compulsory, and due to its character it requires to be evaluated during the development of the module, and cannot be evaluated afterwards.

In addition, for both the continuous and final evaluation, all students will make an exam (30%) on nanodevices and nanoscaling.

Extraordinary call

The paper, monitoring and presentation described above for continuos and global calls are compulsory, and due to their character, they require to be evaluated during the development of the module, and cannot be evaluated afterwards. Their contribution will be up to 70%.

The remminder 30% will be monitored through an individual exam on nanodevices and device scaling.

In all cases, a complementary evaluation might take place to guarantee that original work has been performed.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
B. Rogers, S. Pennathur, J. Adams, Nanotechnology. Understanding small systems, 3rd ed. CRC Press (2014).	Bibliography	Textbook
- S.M. Sze and K.K. Ng, Physics of Semiconductor Devices (3rd Edition) Wiley 2007	Bibliography	Textbook
- S.M. Sze, M.K. Klee, Semiconductor Devices: Physics and Technology (3rd Edition) Wiley 2010	Bibliography	Textbook
- V.V. Mitin, V.A. Kochelap, M.A. Strocio, Introduction to nanoelectronics. Cambridge University Press (2012).	Bibliography	Advanced textbook

- Rainer Waser (editor), Nanoelectronics and Information Technology. John Wiley & Sons (2012).	Bibliography	Advanced textbook
Bharat Bhushan (editor), Springer Handbook of Nanotechnology, 3rd ed. Springer, 2010.	Bibliography	Manual
Transparencias en plataforma Moodle	Others	Contenido de las clases
Mark Lundstrom, https://nanohub.org/resources/5306	Web resource	On-line presentations: simulations
Software: FETToy 2.0 at https://nanohub.org/resources/107	Others	Programa software para simulaciones
Enlaces web	Web resource	Enlaces de asociaciones, centros de I+D, compañías, congresos, etc. relacionados con la asignatura.

9. Other information

9.1. Other information about the subject

Some information on Sustainable Developments Goals of Nanoelectronics will be given in this module, in particular SDG3, 7, 9 and 11.