ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000839 - Nanoelectronics

DEGREE PROGRAMME

09AQ - Master Universitario en Ingenieria de Telecomunicacion

ACADEMIC YEAR & SEMESTER

2020/21 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93000839 - Nanoelectronics
No of credits	6 ECTS
Type	Optional
Academic year ot the programme	Second year
Semester of tuition	Semester 4
Tuition period	February-June
Tuition languages	English
Degree programme	09AQ - Master Universitario en Ingenieria de Telecomunicacion
Centre	09 - Escuela Tecnica Superior de Ingenieros de Telecomunicacion
Academic year	2020-21

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Fernando Calle Gomez (Subject coordinator)	C-225/classroom	fernando.calle@upm.es	M - 15:00 - 16:00 Agree with professors

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

2.2. Research assistants

Name and surname	Email	Faculty member in charge
Pedros Ayala, Jorge	j.pedros@upm.es	Calle Gomez, Fernando

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

- Inglés

4. Skills and learning outcomes *

4.1. Skills to be learned

CE10 - Capacidad para diseñar y fabricar circuitos integrados.

CE13 - Capacidad para aplicar conocimientos avanzados de fotónica y optoelectrónica, así como electrónica de alta frecuencia.

CE15 - Capacidad para la integración de tecnologías y sistemas propios de la Ingeniería de Telecomunicación, con carácter generalista, y en contextos más amplios y multidisciplinares como por ejemplo en bioingeniería, conversión fotovoltaica, nanotecnología, telemedicina.

CG1 - 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.

CG2 - 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.

CG4 - 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.

CG5 - 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.

CT4 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo.

CT5 - Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente.

4.2. Learning outcomes

RA41 - Capacidad de presentar los resultados de lo anterior en grupo de forma oral y escrita

RA76 - Habilidad de comunicación oral y escrita

RA122 - Conocer a nivel básico los procesos tecnológicos que se usan en la fabricación de circuitos integrados

RA125 - Conocer las aplicaciones de las tecnologías microelectrónicas a dispositivos electrónicos particulares como dispositivos pasivos de alta frecuencia, sensores, MEMS, etc.

RA25 - P ráctica de habilidades transversales necesarias para la gestión y participación en proyectos de ingeniería. (CG4, CT2, CT4)

RA72 - Mejora de la capacidad de pensamiento creativo

RA124 - Conocer el concepto de tecnología de fabricación microelectrónica y saber diseñar esquemáticamente una ruta de fabricación de CI

RA10 - Saber realizar una presentación de carácter técnico, ante una audiencia de pares, que describa el trabajo realizado y sus resultados, de forma clara y bien estructurada, en el tiempo establecido, y usando un lenguaje preciso

RA87 - Comprender cómo distintas alternativas de diseño para un circuito integrado CMOS afectan a su área, velocidad, consumo de potencia, fiabilidad y coste.

* 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

Current electronic systems include in an increasing number sensors, actuators and interfaces with the user which are real micro and nanosystems (MS and NS). This is even more relevant in pprtable systems where the functionality, the improvement in performance and energy issues are promoting the nanoelectronics technology for the applicatjons and also for energy harvesting and storage. Smartphones are one clear paradigm of such trends. Other examples of this social impact are taking place in the field of biomedicine. The commercial availability of the so-called lab-on-a chip and lab-in-a-system, genuine MS and NS which involve nanosensors and integrated intelligence. Many of these devices and systems are routinely used in analytical studies in hospitals, as well as many sensoric implants are promoting the developement of new advances in MS and NS.

From the aspect of contents, two main goals are pursued,

- To know and review a general sight of microsystems and nanoelectronics (NE), to study the working principles and the fabrication of MS and NE in the above mentioned fields.

- To know mico and nanoelectronic devices beneath micro and nanosystems, and to evaluate their properties using new materials and scale shrinking.

From the view of aptitudes, this module objectives are to strengthen the students ability to think and relate contents; to search, produce and present information; and to integrate knowledge.

This module program include two parts:

1. Some lessons on the principles on nanotechnology, nanomaterials, the fabrication and characterisation procedures, and a review of the market of micro and nanosystems.

2. Several simulation practices of advanced nanodevices for some of the above applications. Several cases will be selected, including scaled-down MOSFETS, nanowires based transistors, and CNT and graphene nanoribbon-based devices. The students are expected to develope abilities to critically evaluate the parameters, show the results and integrate them to extract conclusions and improve the device design.

5.2. Syllabus

1. Introduction to micro and nanosystems

   1.1. Introduction to nanotechnology

   1.2. Nanomaterials and nanostructures based in semiconductors, carbon and organic materials

   1.3. Techniques for fabrication and characterization of nanodevices

2. Simulations

   2.1. Principles of simulations. Software FETToy 2.0: device, model, conditions, outputs

   2.2. Simulation 1: Introduction to the MOSFET

   2.3. Simulation 2: Scaling down of transistors

   2.4. Simulation 3: Si nanowire MOSFET

   2.5. Simulation 4: CNT and graphene-based MOSFET

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1	**1. Introduction to micro and nanosystems. 1.1. Introduction to nanotechnology 1.2 Nanomaterials and nanostructures** Duration: 04:00 Lecture			
2	**1.2 Nanotechniques for Fabrication and Characterization** Duration: 02:00 Lecture	**1.3 Nanotechniques for Fabrication and Characterization: Visit to ISOM labs** Duration: 02:00 Additional activities		
3	**2. Introduction to simulations 2.1. Principles of simulation. Software FETToy 2.0: device, model, conditions, outputs** Duration: 04:00 Lecture			
4	**Simulation 1: Introduction to the MOSFET.** Duration: 03:00 Lecture			
5	**Simulation 1: Introduction to the MOSFET.** Duration: 04:00 Laboratory assignments			
6	**Simulation 2: Transistor scaling** Duration: 04:00 Laboratory assignments			**Report Simulation 1** Individual presentation Continuous assessment Presential Duration: 00:00
7	**Simulation 2: Transistor scaling** Duration: 04:00 Laboratory assignments			
8	**Simulation 2: Transistor scaling** Duration: 04:00 Laboratory assignments			
9	**Simulation 3: Si nanowire MOSFET** Duration: 04:00 Laboratory assignments			**Report Simulation 2** Individual presentation Continuous assessment Presential Duration: 00:00
10	**Simulation 3: Si nanowire MOSFET** Duration: 04:00 Laboratory assignments			

11	**Simulation 3: Si nanowire MOSFET** Duration: 04:00 Laboratory assignments			
12	**Simulation 4: CNT/graphene MOSFET** Duration: 04:00 Laboratory assignments			**Report Simulation 3** Individual presentation Continuous assessment Presential Duration: 00:00
13	**Simulation 4: CNT/graphene MOSFET** Duration: 04:00 Laboratory assignments			
14	**Simulation 4: CNT/graphene MOSFET** Duration: 04:00 Laboratory assignments			
15				**Report Simulation 4** Individual presentation Continuous assessment Presential Duration: 00:00
16				
17				**Reports and/or Final exam** Other assessment 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.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
6	Report Simulation 1	Individual presentation	Face-to-face	00:00	25%	3 / 10	CG4 CG2 CT5 CT4 CG1 CG5 CE10 CE13 CE15
9	Report Simulation 2	Individual presentation	Face-to-face	00:00	25%	3 / 10	CT5 CT4 CG1 CG5 CG4 CG2 CE10 CE13 CE15
12	Report Simulation 3	Individual presentation	Face-to-face	00:00	25%	3 / 10	CG4 CG2 CT5 CT4 CG1 CG5 CE10 CE13 CE15
15	Report Simulation 4	Individual presentation	Face-to-face	00:00	25%	3 / 10	CG4 CG2 CT5 CT4 CG1 CG5 CE10 CE13 CE15

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17	Reports and/or Final exam	Other assessment	Face-to-face	02:00	100%	5 / 10	CG4 CG2 CT5 CT4 CG1 CG5 CE10 CE13 CE15

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Reports and/or Final exam	Other assessment	Face-to-face	02:00	100%	5 / 10	CG4 CG2 CT5 CT4 CG1 CG5 CE10 CE13 CE15

7.2. Assessment criteria

The "continuous evaluation procedure" includes four activities, each one accounts for 25% of the marks:

- Four reports on the respective simulation practices

This procedure is the one taking into account the Bolonia guidelines.

The students who decide to attend only the Final exam, should write a letter to the responsible of the module during the first month of the semester. In order to be properly evaluated of all the skills of the module, these students will also pass an exam and deliver the reports of all the simulation practices on the date of the final exam or any other previously agreed with the professors.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
B. Rogers, S. Pennathur, J. Adams, Nanotechnology. Understanding small systems, 2nd ed. CRC Press (2011).	Bibliography	Libro de consulta
R. Kelsall, I.W. Hamley and M. Geoghegan (eds.), Nanoscale Science and Technology, Wiley (2005)	Bibliography	Libro consulta
M. Lundstrom and J. Guo, Nanoscale Transistors: Device Physics, Modeling and Simulation, Springer (2006).	Bibliography	Libro consulta
Bharat Bhushan (editor), Springer Handbook of Nanotechnology, 3rd ed. Springer, 2010.	Bibliography	Manual

Mark Lundstrom, https://nanohub.org/resources/5306	Web resource	On-line presentations: simulations
Transparencias en plataforma Moodle	Others	Contenido de las clases
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

In this module, the content will be presented with a practical and application format.

Some aspects of the methodology and evaluation will depend on the number of registered students. In principle, the simulation practices will be pèrformed by groups of two students.