ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93001323 - Neurodispositivos

DEGREE PROGRAMME

09BQ - Master In Science In Neurotechnology

ACADEMIC YEAR & SEMESTER

2024/25 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93001323 - Neurodispositivos
No of credits	6 ECTS
Type	Compulsory
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	09BQ - Master In Science In Neurotechnology
Centre	09 - Escuela Tecnica Superior De Ingenieros De Telecomunicacion
Academic year	2024-25

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Georgios Kontaxakis Antoniadis (Subject coordinator)	C-229	g.kontaxakis@upm.es	Sin horario. By appointment
Alvaro Araujo Pinto	B-104	alvaro.araujo@upm.es	Sin horario. By appointment
Lucilio Cordero Grande	B-039.A	lucilio.cordero@upm.es	Sin horario. By appointment

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

2.3. External faculty

Name and surname	Email	Institution
Atocha Guedán Durán	maguedanduran@gmail.com	Centro de Tecnologia Biomédica, UPM
José Pérez Rigueiro	jose.perez@upm.es	Departamento de Ciencia de los Materiales
Pablo Sarabia Ortiz	psarabia@b105.upm.es	ETSI Telecomunicación
Francisco Rojo Pérez	fj.rojo@upm.es	Departamento de Ciencia de los Materiales
Gustavo Plaza Baonza	gustavo.plaza@upm.es	Departamento de Ciencia de los Materiales
Rafael Daza García	rafael.daza@upm.es	Departamento de Ciencia de los Materiales
Blanca González Bermúdez	blanca.gbermudez@upm.es	Departamento de Ciencia de los Materiales
Gustavo Victor Guinea Tortuero	gustavovictor.guinea@upm.es	Departamento de Ciencia de los Materiales
Nahla Jemni Damer	nahla.jemni@ctb.upm.es	Centro de Tecnología Biomédica, UPM

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

- Principles of Analogue and Digital Electronics

- Basic Experience in Electronics Instrumentation Laboratories

4. Skills and learning outcomes *

4.1. Skills to be learned

C3 - Concebir, desarrollar y validar nuevos neurodispositivos y neuroprótesis que puedan aumentar la calidad de vida de las personas, y realizar, en contextos académicos y profesionales, innovaciones o avances tecnológicos que puedan hacer avanzar el estado del arte en áreas relacionadas con la neurotecnología. Competencias

C4 - Resolver problemas de neurodispositivos, neuroseñales e inteligencia artificial, integrando conocimiento en aspectos nuevos o escasamente definidos y en entornos multidisciplinares. Competencias

C5 - Aplicar metodologías, procedimientos, herramientas y normas del estado del arte para la creación de nuevos componentes tecnológicos, y construir nuevas hipótesis y modelos, evaluarlos y aplicarlos a la resolución de problemas en el área de la neurotecnología. Competencias

K4 - Comprender los conceptos y técnicas avanzadas de la electrónica, de la instrumentación biomédica y de los biomateriales en la neuroingeniería. Conocimientos.

S1 - Aplicar técnicas de neurotecnología adecuadas (neurodispositivos, neuroprótesis, procesamiento de neuroseñales, inteligencia artificial) ante problemas mixtos tecnológicos y clínicos y entender los desafíos y oportunidades asociados con su aplicación en este campo.Habilidades

S3 - Seleccionar y aplicar técnicas avanzadas para el procesamiento de señales neuroelectrofisiológicas e imágenes cerebrales para diseño, implementación y evaluación de interfaces cerebro-máquina, y dispositivos de neurorehabilitación que permitan diagnosticar y tratar enfermedades neurológicas y neuropsiquiátricas. Habilidades

4.2. Learning outcomes

RA4 - RA-K4,S1,S3,C3,C4,C5

* 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

Neurodevices is an interdisciplinary course designed to bridge the gap between neuroscience, materials science, and electronic engineering. This course provides students with a comprehensive understanding of the principles and applications of neuroelectronics, a field at the forefront of developing advanced technologies for interfacing with the nervous system. Students will gain in-depth knowledge of neurobiomaterials and neurodevices, learning analysis and design principles to implement these cutting-edge tools to explore and manipulate neural activity. The curriculum combines theoretical foundations with practical hands-on experience, preparing graduates to contribute to the development of innovative solutions for neurotechnologies and human-machine interactions.

Central to the program are neurobiomaterials, which are specialized materials engineered to interact with neural tissues. These materials play a critical role in the creation of neurodevices, which are devices designed to monitor, stimulate, or modulate neural activity. Students will explore various types of neurobiomaterials, including biocompatible polymers, nanomaterials, and bioactive substances, understanding their properties and applications in neural interfaces. The course also covers the design principles of neurodevices, such as neural prosthetics, brain-machine interfaces, and biosensors. Through a combination of lectures, laboratory work, and research projects, students will develop the skills necessary to advance the field of neuroelectronics, paving the way for new therapeutic strategies and technological advancements in neuroscience.

5.2. Syllabus

1. Introduction to the course

2. Neuro-Biomaterials

   2.1. Families of Biomaterials

   2.2. Mechanical Properties and Requirements

   2.3. Silk as biomaterial in Neurotechnology: Silk properties

      2.3.1. Silk properties

      2.3.2. High performance fibers for axonal guidance

   2.4. Tissue Engineering

      2.4.1. Biocompatibility

      2.4.2. Principles of Tissue Engineering

   2.5. Tissue Interfaces (Electrodes) in Neuroscience

   2.6. Artificial Synapse

   2.7. Visit to the laboratory of Biomaterials and Regenerative Engineering at the Center for Biomedical Technology

3. Circuit models of neurons

4. Neuroelectronics

   4.1. Sensors

   4.2. Amplification

   4.3. Filtering

   4.4. Digital/Analog conversion

   4.5. Microcontrollers and microprocessors

   4.6. Neuroelectronics systems

      4.6.1. Recording of neuro-biological signals

      4.6.2. Neuro-stimulation techniques

5. Brain computer interfaces

6. Neuromorphic systems

7. Laboratorry experiences with neural recording and stimulation techniques

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	**Presentation of the course and introduction** Duration: 02:00 **Biomaterials: Introduction to biomaterials; groups of biomaterials; mechanical properties** Duration: 02:00			
2	**Circuit models of neurons** Duration: 02:00 **Tissue engineering: Biocompatibility; principles of tissue engineering** Duration: 01:00 **Artificial Synapse: Overview and types; requirements and properties; biomaterials and fabrication** Duration: 01:00	**Visit and practical exercises at the laboratory of Biomaterials and Regenerative Engineering: Experimental set-ups and interactive demonstrations** Duration: 04:00		
3	**Circuit models of neurons** Duration: 02:00 **Silk as neurobiomaterial: Silk properties and formats; silk fibers for axonal guidance** Duration: 01:00 **Neural Interfaces: Types, electrical requirements, mechanical requirements, biomaterials used** Duration: 01:00			
4	**Neuroelectronics: Signal acquisition** Duration: 02:00 **Deep Brain Stimulation** Duration: 02:00			

5	**Neuroelectronics: Signal acquisition** Duration: 02:00 **Transcranial Magnetic Stimulation** Duration: 02:00			
6	**Neuroelectronics: Signal acquisition** Duration: 02:00 **Transcranial Current Stimulation** Duration: 02:00			
7	**Neuroelectronics: Signal processing** Duration: 02:00 **Midterm exam** Duration: 01:00	**Brain Computer Interfaces** Duration: 02:00		**Midterm exam** Progressive assessment Presential Duration: 01:00
8	**Neuroelectronics: Signal processing** Duration: 02:00 **Biosignals: Electromyograms, Electrooculograms** Duration: 02:00			
9	**Neuroelectronics: Signal processing** Duration: 02:00 **Biosignals: Magnetoencephalograms, Optically Pumped Magnetometry** Duration: 02:00			
10	**Neuroelectroics: Power sources** Duration: 02:00 **Neuromorphic systems** Duration: 02:00			
11		**Laboratory Practical Exercises** Duration: 04:00		**Laboratory practical work** Group presentation in the lab Progressive assessment and Global Examination Presential Duration: 00:00
12		**Laboratory Practical Exercises** Duration: 04:00		**Laboratory practical work** Group presentation in the lab Progressive assessment and Global Examination Presential Duration: 00:00

13		**Laboratory Practical Exercises** Duration: 04:00		**Laboratory practical work** Group presentation in the lab Progressive assessment and Global Examination Presential Duration: 00:00
14	**Sesión de problemas y ajuste de programación docente.** Duration: 02:00 **Second midterm exam** Duration: 01:00			**Second midterm exam** Progressive assessment Presential Duration: 01:00
15				
16				
17				**Written exam (global evaluation)** Global 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.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
7	Midterm exam		Face-to-face	01:00	35%	0 / 10	S1 S3 K4
11	Laboratory practical work	Group presentation in the lab	Face-to-face	00:00	10%	0 / 10	C3 C4 C5 S1 S3 K4
12	Laboratory practical work	Group presentation in the lab	Face-to-face	00:00	10%	0 / 10	C3 C4 C5 S1 S3 K4
13	Laboratory practical work	Group presentation in the lab	Face-to-face	00:00	10%	0 / 10	C3 C4 C5 S1 S3 K4
14	Second midterm exam		Face-to-face	01:00	35%	0 / 10	C3 C4 C5 S1 S3 K4

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
11	Laboratory practical work	Group presentation in the lab	Face-to-face	00:00	10%	0 / 10	C3 C4 C5 S1 S3 K4

12	Laboratory practical work	Group presentation in the lab	Face-to-face	00:00	10%	0 / 10	C3 C4 C5 S1 S3 K4
13	Laboratory practical work	Group presentation in the lab	Face-to-face	00:00	10%	0 / 10	C3 C4 C5 S1 S3 K4
17	Written exam (global evaluation)		Face-to-face	02:00	70%	5 / 10	C3 C4 C5 S1 S3 K4

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Written exam		Face-to-face	02:00	70%	5 / 10	
Laboratory exam		Face-to-face	01:00	30%	/ 10	

7.2. Assessment criteria

Evaluation will assess whether students have reached the learning outcomes of the course. Students will pass the course if they obtain a grade greater than or equal to 5 points out of a total of 10. A progressive evaluation scheme based on two midterm exams and practical laboratory exercises will be implemented. If students do not reach a passing grade in the progressive evaluation scheme, they will have the option to renounce the scores of the two written midterm exams and take a global evaluation exercise during the January final exams period (70% of the total score). Attendance and participation in the laboratory sessions will be mandatory. Students who fail to attend a laboratory session will be required to attend a makeup session, which they might have to complete without their group partners.

During the period of extraordinary exams, students will take a written exam (70% of the total score). They can keep their laboratory scores (30%) or choose to repeat the exercises and renounce their original scores.

Copying, plagiarism, or any other form of deception in the submitted works and evaluation activities will result in failure (score: 0) of the corresponding part of the evaluation, according to the UPM evaluation regulations.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Design with Operational Amplifiers and Analog Integrated Circuits	Bibliography	Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits". 4th Edition, Mc Graw Hill, 2016. ISBN: 9352601947
Neural Engineering	Bibliography	Bin He, "Neural Engineering", Springer, 2020. eBook ISBN: 978-3-030-43395-6
Brain-Machine Interface Engineering	Bibliography	Justin C. Sanchez, José C. Príncipe, "Brain-Machine Interface Engineering", Springer, 2022. ISBN: 9783031016219.
Handbook of Neuroengineering	Bibliography	Nitish V. Thakor, "Handbook of Neuroengineering", Springer, 2023 eBook ISBN: 978-981-16-5540-1
Moodle	Web resource	UPM Official Moodle Platform

9. Other information

9.1. Other information about the subject

This course contributes to the Agenda 2030 Sustainable Development Goals (SDG), particularly to SDG 3.