



POLITÉCNICA

INTERNATIONAL
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COORDINATION PROCESS OF
LEARNING ACTIVITIES
PR/CL/001



E.T.S. de Ingenieros
Industriales

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

53001589 - Nuclear Fusion

DEGREE PROGRAMME

05BF - Master Universitario En Ciencia Y Tecnologia Nuclear

ACADEMIC YEAR & SEMESTER

2025/26 - Semester 2

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1. Description

1.1. Subject details

Name of the subject	53001589 - Nuclear Fusion
No of credits	3 ECTS
Type	Compulsory
Academic year of the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	05BF - Master Universitario en Ciencia y Tecnología Nuclear
Centre	05 - E.T.S. De Ingenieros Industriales
Academic year	2025-26

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Eduardo Oliva Gonzalo	ETSII - Nuclear	eduardo.oliva@upm.es	Sin horario. It is necessary to request tutoring by email.
Pedro Velarde Mayol	ETSII - Nuclear	pedro.velarde@upm.es	Sin horario. It is necessary to request tutoring by email.

Manuel Cotelo Ferreiro (Subject coordinator)	ETSII - Nuclear	manuel.cotelo@upm.es	Sin horario. It is necessary to request tutoring by email.
Elisa Alejandra Vazquez Fernandez Tello	ETSII - Nuclear	ea.vazquez@upm.es	Sin horario. It is necessary to request tutoring by email.

* 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

- Física Nuclear
- Teoría Del Transporte De Partículas Y Radiación

3.2. Other recommended learning outcomes

- Estructura de la materia
- Electromagnetismo
- Mecánica de fluidos

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

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

CE01 - Entiende a fondo las leyes básicas y avanzadas de la física atómica y nuclear y las ciencias de la ingeniería pertinentes aplicables a la tecnología de las plantas de energía nuclear de fisión y/o fusión

CE06 - Concibe la utilización de los aceleradores de partículas como herramientas avanzadas en la investigación física, y sus aplicaciones en la medicina e industria

CG01 - Tener conocimientos avanzados de los aspectos científicos y tecnológicos de la energía nuclear

CG04 - Ser capaz 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

CT08 - Entiende los impactos. Educación amplia necesaria para entender el impacto de las soluciones ingenieriles en un contexto social global

CT10 - Conoce. Conocimiento de los temas contemporáneos

4.2. Learning outcomes

RA10 - Entender de los Principios de la Tecnología de Generación de Energía por Fusión Nuclear por Confinamiento Magnético e Inercial

RA11 - Analizar el estado de instalaciones actuales y futuras. Sistemas y Materiales.

RA9 - Conocer los Principios de la Física de los Plasmas de alta y baja densidad con o sin campos electromagnéticos

* 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

This subject provides a comprehensive overview of nuclear fusion, covering everything from the fundamental plasma physics to the reactor engineering challenges and the profound societal impact of fusion energy. We'll explore magnetic confinement fusion (MFE), diving into the behavior of high-temperature plasmas with topics like kinetic and fluid descriptions, magnetohydrodynamics (MHD), plasma waves, and instabilities relevant to tokamaks and stellarators. We'll also examine the theoretical and experimental aspects of MFE, including plasma heating, current drive, and performance limits. Concurrently, we'll explore inertial confinement fusion (IFE), focusing on laser-plasma interactions, implosion dynamics, and target design. Finally, we'll delve into the engineering principles of future fusion power plants, addressing reactor concepts, blanket design, material challenges, superconducting magnets, and the safety and environmental considerations that will shape our energy future.

5.2. Syllabus

1. Nuclear Fusion fundamentals
 - 1.1. Nuclear Fusion reaction and reaction kinetics
 - 1.2. Plasma physics applied to Nuclear Fusion
2. Nuclear Fusion plasmas
 - 2.1. Inertial Confinement
 - 2.1.1. Target characteristics
 - 2.1.2. Driver-target interaction
 - 2.1.3. Hydrodynamic compression
 - 2.1.4. Ignition schemes
 - 2.1.5. Energy gain and yield
 - 2.2. Magnetic confinement
 - 2.2.1. Tokamak and stellarator
 - 2.2.2. Plasma heating
 - 2.2.3. Ignition and gain
 - 2.2.4. Border effects
 - 2.2.5. Instabilities
3. Nuclear Fusion power plant technologies
 - 3.1. Radiation-matter interaction
 - 3.2. Inertial confinement
 - 3.2.1. Power plant systems
 - 3.2.2. Reaction chamber characteristics
 - 3.2.3. From NIF and LMJ to a power plant
 - 3.3. Magnetic confinement
 - 3.3.1. Heating technologies
 - 3.3.2. First wall, divertor and breeding blanket
 - 3.3.3. From JET and ITER to a power plant

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	Face to face lesson Duration: 02:00 Lecture			
2	Face to face lesson Duration: 02:00 Lecture			
3	Face to face lesson Duration: 02:00 Lecture			
4	Face to face lesson Duration: 02:00 Lecture			
5	Face to face lesson Duration: 02:00 Lecture			Delivery of exercises Individual work Progressive assessment and Global Examination Not Presential Duration: 08:00
6	Face to face lesson Duration: 02:00 Lecture			
7	Face to face lesson Duration: 02:00 Lecture			
8	Face to face lesson Duration: 02:00 Lecture			
9	Face to face lesson Duration: 02:00 Lecture			Delivery of exercises Individual work Progressive assessment and Global Examination Not Presential Duration: 08:00
10	Face to face lesson Duration: 02:00 Lecture			
11	Lección presencial (Face to face lesson) Duration: 01:00 Lecture Clase práctica de ejercicios en python (Hand on python exercises) Duration: 01:00 Problem-solving class			

12	Face to face lesson Duration: 02:00 Lecture			
13	Face to face lesson Duration: 02:00 Lecture			
14	Face to face lesson Duration: 02:00 Lecture			Exam Individual presentation Progressive assessment and Global Examination Presential Duration: 01:00
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.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
5	Delivery of exercises	Individual work	No Presential	08:00	20%	4 / 10	CG01 CT08 CE01 CB06
9	Delivery of exercises	Individual work	No Presential	08:00	20%	4 / 10	CB08 CB06 CE06 CG04
14	Exam	Individual presentation	Face-to-face	01:00	60%	4 / 10	CT10 CG01 CG04 CB06 CB08

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
5	Delivery of exercises	Individual work	No Presential	08:00	20%	4 / 10	CG01 CT08 CE01 CB06
9	Delivery of exercises	Individual work	No Presential	08:00	20%	4 / 10	CB08 CB06 CE06 CG04
14	Exam	Individual presentation	Face-to-face	01:00	60%	4 / 10	CT10 CG01 CG04 CB06 CB08

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

Your final grade for this subject will be based on two components:

- Exercises: 40% of your final grade. These must be submitted via the Moodle platform.
- Exam: 60% of your final grade. This will include both multiple-choice questions and short problems.

Please note that you must achieve a minimum score of 4 out of 10 on each of these activities to pass the subject

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Bibliography	Bibliography	Relevant bibliographic references with comments
Web resources	Web resource	Open software, reference web pages and other resources)
Course notes	Others	Notes of the lessons covering the whole content of the course
Moodle	Web resource	

9. Other information

9.1. Other information about the subject

Students will have access to all the resources and activities through the UPM's Moodle platform. Communication between students and teachers will preferably be done through the Moodle platform.

Nuclear Fusion is a new source of energy with enormous potential to be exploited. This potential can help us achieve several of the Sustainable Development Goals:

- **SDG7 Affordable and non-polluting energy:** The potential for exploiting Nuclear Fusion is virtually inexhaustible. Therefore, sustainable use of this energy source can be made over time and it is also based on very abundant resources, so any nation can access this energy source. It is also an energy source with low greenhouse gas emissions and the generation of radioactive waste is much more limited than in nuclear fission technology.
- **SDG9 Industrial, innovation and infrastructure:** The development of Nuclear Fusion still requires the development of new techniques and materials to be able to exploit it in a controlled and safe manner. These developments will generate a technological advance that the industry can take advantage of and therefore make the economies of the countries grow.
- **SDG13 Climate action:** As Nuclear Fusion is a technology for energy production with low greenhouse gas emissions, it helps us mitigate climate change by reducing emissions from energy production.