



INTERNATIONAL
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PR/CL/001



E.T.S. de Ingenieros
Industriales

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

53002038 - Nuclear Fusion Technology

DEGREE PROGRAMME

05BK - Máster Universitario En Ingeniería De La Energía

ACADEMIC YEAR & SEMESTER

2025/26 - Semester 2

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1. Description

1.1. Subject details

Name of the subject	53002038 - Nuclear Fusion Technology
No of credits	3 ECTS
Type	Optional/elective
Academic year of the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	05BK - Máster Universitario en Ingeniería de la Energía
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 *
Elisa Alejandra Vazquez Fernandez Tello	ETSII - Nuclear	ea.vazquez@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.

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.

* 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

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Estructura de la materia
- Teoría del transporte de partículas y radiaciones
- Tecnología Nuclear
- Electromagnetismo

4. Skills and learning outcomes *

4.1. Skills to be learned

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.

CB7 - 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

CB9 - 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

CE15 - Conocer los criterios básicos de seguridad y protección radiológica, el impacto de las radiaciones ionizantes y las tecnologías del blindaje contra las mismas.

CE17 - Comprender los procesos que integran el ciclo de vida de los procesos energéticos, desde la obtención del recurso primario, hasta su desmantelamiento, y su integración en la economía circular.

CE3 - Utilizar las herramientas necesarias para el diseño y análisis de sistemas de generación, transformación, almacenamiento y utilización de energías nucleares, mecánicas, eléctricas, térmicas e hidráulicas.

CE8 - Disponer de habilidades, criterios y conocimientos para investigar, desarrollar e innovar en el campo de la energía: tecnologías renovables y no renovables, almacenamiento, vectores energéticos, en un contexto de decarbonización del sistema.

CG1 - Aplicar conocimientos de ciencias y tecnologías avanzadas a la práctica profesional o investigadora de la Ingeniería Energética.

CT10 - Conoce. Conocimiento de los temas contemporáneos.

CT12 - Es bilingüe. Capacidad de trabajar en un entorno bilingüe (inglés/español).

CT7 - Comunica. Habilidad para comunicar eficazmente.

CT8 - Entiende los impactos. Educación amplia necesaria para entender el impacto de las soluciones ingenieriles en un contexto social global.

4.2. Learning outcomes

RA71 - Entender de los Principios de la Tecnología de Generación de Energía por Fusión Nuclear por Confinamiento Magnético e Inercial.

RA73 - Identificar las funciones y sistemas necesarios para el funcionamiento de una instalación de Fusión Nuclear y sus restricciones.

RA72 - Conocer y analizar el estado actual de las instalaciones de Fusión Nuclear por confinamiento magnético e inercial.

* 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 course 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. Initiation 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			
6	Face to face lesson Duration: 02:00 Lecture			
7	Face to face lesson Duration: 02:00 Lecture			Delivery of exercises Individual work Progressive assessment and Global Examination Not Presential Duration: 08:00
8	Face to face lesson Duration: 02:00 Lecture			
9	Face to face lesson Duration: 02:00 Lecture			
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			Delivery of exercises Individual work Progressive assessment and Global Examination Not Presential Duration: 08:00
15				
16				
17				Exam Written test Progressive assessment and Global Examination Presential Duration: 01:00

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	Delivery of exercises	Individual work	No Presential	08:00	20%	4 / 10	CE3 CE15 CE8 CE17 CG1 CB7
14	Delivery of exercises	Individual work	No Presential	08:00	20%	4 / 10	CE3 CE15 CE8 CE17 CG1 CB7
17	Exam	Written test	Face-to-face	01:00	60%	4 / 10	CB7 CB9 CB10 CT10 CT7 CT8 CT12 CE17

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
7	Delivery of exercises	Individual work	No Presential	08:00	20%	4 / 10	CE3 CE15 CE8 CE17 CG1 CB7
14	Delivery of exercises	Individual work	No Presential	08:00	20%	4 / 10	CE3 CE15 CE8 CE17 CG1 CB7

17	Exam	Written test	Face-to-face	01:00	60%	4 / 10	CB7 CB9 CB10 CT10 CT7 CT8 CT12 CE17
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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.