ANX-PR/CL/001-01
LEARNING GUIDE

SUBJECT

53001594 - Materials Under Irradiation

DEGREE PROGRAMME

05BF - Master Universitario En Ciencia Y Tecnologia Nuclear

ACADEMIC YEAR & SEMESTER

2022/23 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	53001594 - Materials Under Irradiation
No of credits	3 ECTS
Type	Compulsory
Academic year ot the programme	First year
Semester of tuition	Semester 1 Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	05BF - Master Universitario en Ciencia y Tecnologia Nuclear
Centre	05 - Escuela Técnica Superior De Ingenieros Industriales
Academic year	2022-23

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Antonio Juan Rivera De Mena	IFN	antonio.rivera@upm.es	Sin horario. To be arranged with the professor
Ovidio Yordanis Peña Rodriguez (Subject coordinator)	IFN	ovidio.pena@upm.es	Sin horario. To be arranged with the professor

Raquel Gonzalez Arrabal	IFN	raquel.gonzalez.arrabal@upm.es	Sin horario. To be arranged with the professor
David Garoz Gomez	IFN	david.garoz@upm.es	Sin horario. To be arranged with the professor

* 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
Jorge Kohanoff	j.kohanoff@upm.es	IFN-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

- Solid state physics

- Materials science

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

CB07 - 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

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

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

CG02 - Realizar investigación, desarrollo e innovación en procesos y métodos aplicables a los sistemas de fisión o fusión nuclear

CT02 - Experimenta. Habilidad para diseñar y realizar experimentos así como analizar e interpretar datos

CT04 - Trabaja en equipo. Habilidad para trabajar en equipos multidisciplinares

CT11 - Usa herramientas. Habilidad para usar las técnicas, destrezas y herramientas ingenieriles modernas necesarias para la práctica de la ingeniería

CT14 - Idea. Creatividad

4.2. Learning outcomes

RA2 - Conocimiento de las técnicas de medida basadas en las propiedades nucleares

RA35 - Saber aplicar e integrar sus conocimientos, la comprensión de estos, su fundamentación científica y sus capacidades de resolución de problemas en entornos nuevos y definidos de forma imprecisa, incluyendo contextos de carácter multidisciplinar tanto investigadores como profesionales altamente especializados.

RA37 - Ser capaces de asumir la responsabilidad de su propio desarrollo profesional y de su especialización en uno o más campos de estudio.

RA36 - Ser capaces de predecir y controlar la evolución de situaciones complejas mediante el desarrollo de nuevas e innovadoras metodologías de trabajo adaptadas al ámbito científico/investigador, tecnológico o profesional concreto, en general multidisciplinar, en el que se desarrolle su actividad.

RA38 - Sistemas y Materiales involucrados en la Fusión 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

The main objective of this subject is to understand the effects of irradiation on materials, particularly the influence of radiation-induced damage over the material properties. We will study the radiation fluxes produced on different nuclear facilities and at different locations within them, as well as the thermomechanical, atomistic and electronic effects produced by the radiation. As part of the course, we will learn to use various simulation codes, to calculate the effects of radiation-induced damage in the diverse energy regimes. Finally, we will discuss the capabilities and limitations of several experimental techniques for characterization radiation-induced damage.

5.2. Syllabus

1. Introduction

2. Thermomechanical effects

3. Atomistic effects

4. Effects of high electronic excitation

5. Macroscopic effects

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**1. Introduction** Duration: 02:00			
2	**2.1. Thermomechanical effects** Duration: 02:00			
3	**2.2. Thermomechanical effects** Duration: 02:00			
4	**3.1. Atomistic effects** Duration: 02:00			
5	**3.2. Atomistic effects** Duration: 02:00			
6	**3.3. Atomistic effects (Computer simulations)** Duration: 02:00			
7	**4.1. Effects of high electronic excitation** Duration: 02:00			
8	**4.2. Effects of high electronic excitation** Duration: 02:00			
9	**4.3. Effects of high electronic excitation (Computer simulations)** Duration: 02:00			
10		**Visit to experimental facility** Duration: 02:00		
11	**5.1. Macroscopic effects** Duration: 02:00			
12	**5.2. Macroscopic effects** Duration: 02:00			**Deliveries, mandatory and non-recoverable** Continuous assessment and final examination Not Presential Duration: 00:00

13	**5.3. Macroscopic effects (Processing of experimental data)** Duration: 02:00			
14	**Discussion of deliveries** Duration: 00:00			
15				**Global evaluation** Continuous assessment and final examination Presential Duration: 02:00
16				
17				**Extraordinary evaluation** Continuous assessment and 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. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
12	Deliveries, mandatory and non-recoverable		No Presential	00:00	40%	5 / 10	CT04 CB07 CB09 CT02 CT11
15	Global evaluation		Face-to-face	02:00	60%	5 / 10	CB06 CE06 CT14 CE01 CG02
17	Extraordinary evaluation		Face-to-face	02:00	60%	5 / 10	CE01 CG02 CB06 CE06 CT14

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
12	Deliveries, mandatory and non-recoverable		No Presential	00:00	40%	5 / 10	CT04 CB07 CB09 CT02 CT11
15	Global evaluation		Face-to-face	02:00	60%	5 / 10	CB06 CE06 CT14 CE01 CG02
17	Extraordinary evaluation		Face-to-face	02:00	60%	5 / 10	CE01 CG02 CB06 CE06 CT14

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

Two deliveries will be published at the beginning of the course. They are compulsory and non-recoverable. Each of them is worth 2 points (in total, 40% of the final grade), and they will be considered both in the ordinary and extraordinary calls.

1.-Ordinary call:
1.1.- Written exam: 60% of the final grade
1.2.- Deliveries: 40% of the final grade

2.- Extraordinary call:
2.1.- Written exam: 60% of the final grade
2.2.- Deliveries: 40% of the final grade

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
G.S. Was, Fundamentals of Radiation Materials Science, Springer (2007), ISBN 978-1-4939-3438-6	Bibliography	
A. Rivera Noviembre 2012. Apuntes Interacción Radiación - Materia	Bibliography	
J. F. Ziegler, M. D. Ziegler, J. Biersack: The Stopping and Range of Ions in Solids, ISBN-13: 978-0080216034	Bibliography	

D Garoz, R González-Arrabal, R Juárez, J Álvarez, J Sanz, J M Perlado and A Rivera. Silica final lens performance in laser fusion facilities: HiPER and LIFE. Nuclear Fusion 53(1):013010, Enero 2013.	Bibliography	
D Garoz, A R Páramo, A Rivera, J M Perlado and R González-Arrabal. Modelling the thermomechanical behaviour of the tungsten first wall in HiPER laser fusion scenarios. Nuclear Fusion 56(12):126014, 2016	Bibliography	
O Peña-Rodríguez, M L Crespillo, P Díaz-Nuñez, J M Perlado, A Rivera and J Olivares. In situ monitoring the optical properties of dielectric materials during ion irradiation. Optical Materials Express 6(3):734?742, 2016	Bibliography	
J Alvarez, D Garoz, R Gonzalez-Arrabal, A Rivera and M Perlado. The role of spatial and temporal radiation deposition in inertial fusion chambers: the case of HiPER. Nuclear Fusion 51(5):053019, Mayo 2011	Bibliography	
www.srim.org	Web resource	
M. Born, E. Wolf, Principles of optics: Electromagnetic theory of propagation, interference and diffraction of light, 7th ed., Cambridge University Press, UK, 1999.	Bibliography	
An introduction to computational Physics. Tao Pang. Cambridge University Press	Bibliography	

D. K. AvasthiG. K. Mehta, Swift Heavy Ions for Materials Engineering and Nanostructuring, 978-94-007-1229-4	Bibliography	
Primary Radiation Damage in Materials, Nuclear Science, NEA/NSC/DOC(2015)9, www.oecdnea. org	Bibliography	
Konings, Allen, Stoller, and Yamanaka Comprehensive Nuclear Materials, Editors:, Elsevier, 2012, ISBN: 008056027X	Bibliography	

9. Other information

9.1. Other information about the subject

SDG2 Zero Hunger: Radiation techniques can be used to improve food security and agriculture. They serve a variety of purposes, from conserving soil, water, and agricultural resources, to protecting plants from insect pests, and raising new varieties of plants with desirable characteristics. For food preparation and preservation, irradiation techniques can be used to ensure higher quality, longer shelf life, and increased food safety.

SDG3 Health and wellness: The development of Irradiation Techniques has given rise to new diagnostic and treatment techniques through Radiography, Radiotherapy and Nuclear Medicine. They can be used to treat cancer and to control and evaluate other health conditions, such as cardiovascular disease or tuberculosis.

SDG7 Affordable and clean energy: Access to clean, reliable and affordable energy is a precondition for sustainable economic growth and the improvement of human well-being. It encourages the efficient and safe use of nuclear energy to safely meet growing energy demands for development, while improving energy security, reducing the environmental and health effects of energy production, and mitigating climate change.

SDG9 Industry, innovation and infrastructure: Leading-edge industrial technologies underpin the success of strong economies, in both developed and developing countries. Nuclear science and technology, in particular, can make an important contribution to economic growth and play an important role in supporting sustainable development. Each country's economies can increase the competitiveness of their industries by using nuclear technologies to conduct safety and quality tests in the industry and by applying irradiation techniques to improve product durability. Irradiation also improves industrial sustainability by helping to reduce the environmental impact of industrial production.

SDG13 Climate action: Nuclear science, including nuclear energy, can play an important role in both mitigation and adaptation to climate change. Nuclear energy can play a relevant role in relation to climate change and the reduction of greenhouse gas emissions. Nuclear power is one of the lowest carbon-emitting technologies available to generate electricity. It helps countries to use nuclear techniques to adapt and mitigate the consequences of climate change through management of soil, water and crop resources and scientific research with nuclear tools.

SDG17 Partnerships to achieve the goals: Partnerships help expand access to science and technology to achieve the SDGs. Close collaboration between the IAEA, United Nations organizations, such as FAO and the World Health Organization, and other international and civil society organizations help maximize the contribution of IAEA support to achieving development priorities. of the countries.