



UNIVERSIDAD
POLITÉCNICA
DE MADRID

PROCESO DE
COORDINACIÓN DE LAS
ENSEÑANZAS PR/CL/001



E.T.S. de Ing. de Caminos
Canales y P.

ANX-PR/CL/001-01

GUÍA DE APRENDIZAJE

ASIGNATURA

43000613 - Materials For Extreme Conditions

PLAN DE ESTUDIOS

04AN - Master Universitario En Ingeniería De Materiales

CURSO ACADÉMICO Y SEMESTRE

2025/26 - Segundo semestre

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1. Datos descriptivos

1.1. Datos de la asignatura

Nombre de la asignatura	43000613 - Materials For Extreme Conditions
No de créditos	3 ECTS
Carácter	Optativa
Curso	Primer curso
Semestre	Segundo semestre
Período de impartición	Febrero-Junio
Idioma de impartición	Inglés/Castellano
Titulación	04AN - Master Universitario en Ingeniería de Materiales
Centro responsable de la titulación	04 - E.T.S. De Ing. De Caminos Canales Y P.
Curso académico	2025-26

2. Profesorado

2.1. Profesorado implicado en la docencia

Nombre	Despacho	Correo electrónico	Horario de tutorías *
Elena Maria Tejado Garrido (Coordinador/a)	ETSI Caminos	elena.tejado@upm.es	M - 11:00 - 13:00 M - 15:00 - 18:00 X - 11:00 - 13:00 X - 15:00 - 17:00 Students may agree on a more convenient date/hour by contacting by email: elena.tejado@upm.

			es
Jaime Orellana Barrasa	ETSI Caminos	jaime.orellana@upm.es	L - 15:00 - 17:00 X - 15:00 - 17:00 J - 15:00 - 17:00 Upon request
Sandra Tarancon Roman	ETSI Caminos	sandra.tarancon@upm.es	L - 12:00 - 14:00 M - 12:00 - 14:00 X - 12:00 - 14:00 Upon request

* Las horas de tutoría son orientativas y pueden sufrir modificaciones. Se deberá confirmar los horarios de tutorías con el profesorado.

3. Conocimientos previos recomendados

3.1. Asignaturas previas que se recomienda haber cursado

- Properties Of Materials

3.2. Otros conocimientos previos recomendados para cursar la asignatura

- Structure of the matter
- Physics and chemistry
- Materials Science and Engineering
- Manufacturing technologies
- Ceramic Materials

4. Competencias y resultados de aprendizaje

4.1. Competencias

CE1 - Capacidad para aplicar los fundamentos científicos del comportamiento físico y químico de los materiales para relacionar causalmente sus propiedades fundamentales físicas y químicas con su comportamiento macroscópico y el de los productos con ellos realizados / Ability to apply the scientific foundations of the physical and chemical behavior of materials to correlate their fundamental physical and chemical properties with their macroscopic behavior and that of the products made with them.

CE3 - Capacidad de diseñar, modelizar, evaluar, seleccionar, fabricar y utilizar materiales con propiedades específicas (estructurales y funcionales) para satisfacer

CE4 - Autonomía para adquirir, analizar, actualizar y aplicar nuevos conocimientos, modelos y técnicas experimentales y numéricas en relación con la composición y estructura de los materiales, su caracterización física y química, sus procesos de fabricación, su utilización y aplicación científica y tecnológica, y su reciclado, reutilización y eliminación / Autonomy to acquire, analyze, update and apply new knowledge, models and experimental and numerical techniques related to the composition and structure of materials, their physical and chemical characterization, their manufacturing processes, their use and scientific and technological application, and their recycling, reuse and disposal

CE5 - Capacidad para planificar, explotar y gestionar técnicamente la selección, fabricación, procesado, utilización, reciclado, reutilización y eliminación de materiales, de forma respetuosa con el medio ambiente, de conformidad con la legislación nacional e internacional, y promoviendo el desarrollo sostenible y el bienestar de la sociedad / Ability to technically plan, exploit and manage the selection, manufacturing, processing, use, recycling, reuse and disposal of materials, in an environmentally friendly manner, in accordance with national and international legislation, and promoting sustainable development and well-being of the society

CG1 - Uso de la lengua inglesa: Los alumnos son capaces de transmitir conocimientos y expresar ideas y argumentos de manera clara, rigurosa y convincente, tanto de forma oral como escrita, adaptándose a las características de la situación y de la audiencia / Use of the English Language: Students are able to transmit knowledge and express ideas and arguments in a clear, rigorous and convincing manner, both orally and in writing, adapting to the characteristics of the situation and the audience .

CG7 - Uso de las TIC: Los alumnos son capaces de aplicar conocimientos tecnológicos necesarios de manera que les permitan desenvolverse cómodamente y afrontar los retos que la sociedad les va a imponer en su quehacer profesional empleando la informática / Use of ICT: Students are able to apply the necessary technological knowledge in a way that allows them to function comfortably and face the challenges that society is going to impose on them in their professional work using computers.

4.2. Resultados del aprendizaje

RA13 - Knowledge and understanding of how radiation affect the behaviour of materials.

RA14 - Knowledge and basic fabrication methods, structure and properties of refractory materials

RA12 - Knowledge and understanding of how extreme temperatures affect the behaviour of materials.

RA15 - Know, understand and correlate the behavior of materials under different environments with their structure, properties, processing and applications.

5. Descripción de la asignatura y temario

5.1. Descripción de la asignatura

Course description

Structural materials play an essential role in many applications, from aeroplane fuselage to car chassis, to computer and cell phone cases. Advanced applications often require materials that are stronger and lighter, as illustrated by the current development in carbon composites and nickel-base alloys.

Furthermore, these materials often operate in harsh environments where they have to maintain their high performance. Turbine blades in jet engines, for instance, operate close to their melting point in an oxidative environment; structural and cladding materials in nuclear reactors are subjected to radiation and corrosion. Besides, limits on material behaviour are among the greatest technical obstacles to improving the safety and economic performance of nuclear energy systems. Next-generation fast fission reactors and future fusion devices will need to overcome even more severe materials challenges, including high atomic displacement rates together with proton/helium production in the fast neutron spectrum. The need to develop materials that can perform well in these severe operating environments is a major challenge for materials science and requires a fundamental understanding of material response under extreme conditions of radiation flux, temperature, and stress.

In contrast, there are other materials whose field of application is that of extremely low temperatures, since only

there do they exhibit such interesting properties as superconductivity.

This course will review basic concepts, which underpin how the material behaves under extreme thermal and mechanical conditions, as well as high-energy irradiations. The emphasis is on qualitative description, providing basic science background, and avoiding unnecessary mathematical formalism. Engineering materials that can withstand harsh environments and new materials with unique compositions/microstructures will be surveyed.

Course topics

The course will be roughly divided into four sections, as indicated in the Course Syllabus:

1. Refractory ceramic materials
2. Composites for extreme in-service applications
3. Metals under extreme in-service conditions, i.e. irradiation environments.
4. Materials for low-temperature applications, i.e. Superconductors

5.2. Temario de la asignatura

1. REFRACTORY CERAMIC MATERIALS

1.1. Refractory materials

- 1.1.1. Introduction to refractory ceramic science
- 1.1.2. Feedstock for refractory ceramic materials production
- 1.1.3. Main properties of refractory ceramic materials
- 1.1.4. Fabrication processes of refractory ceramic materials

1.2. Main refractory ceramic materials

- 1.2.1. Classifications of refractory ceramic materials
- 1.2.2. Refractory lining

1.3. Refractory ceramic materials today

- 1.3.1. Main uses of refractory ceramic materials
- 1.3.2. Refractory ceramic materials for metals obtaining and metals recycling

1.3.3. Refractory ceramic materials for cement and lime production

1.3.4. Refractory ceramic materials for energy production

1.4. Advanced refractory materials

2. COMPOSITES FOR EXTRE IN-SERVICE APPLICATIONS

2.1. Composites basics

2.1.1. Introduction

2.1.2. CMCs for nuclear energy applications

2.1.3. CMCs for aerospace applications

2.2. Ultra-high temperature ceramic-based composites

2.2.1. Introduction

2.2.2. Fabrication processes for UHTCs

2.2.3. Main properties of UHTCs

2.2.4. Protection against oxidation

2.3. Thermal barrier materials

2.3.1. Thermal conductivity of high-temperature materials

2.3.2. Current thermal barrier materials

2.3.3. Future directions for alternative TBC materials

3. MATERIALS FOR LOW-TEMPERATURE APPLICATIONS, I.E. SUPERCONDUCTORS (SC)

3.1. Superconductor materials I

3.1.1. Introduction: history and conductivity in metals and alloys

3.1.2. Phenomenological models of superconductivity

3.1.3. Properties of SC materials

3.1.4. Classification of SC materials

3.2. Superconductor materials II

3.2.1. High temperature superconductors

3.2.2. Processing of SC: bulk and tapes

3.2.3. Applications of SC

3.2.4. Recent advances in SC production

3.3. Superconductor materials III:

3.3.1. Laboratory practice on the Meissner Effect in SC materials

4. MATERIALS SUBJECTED TO RADIATION ENVIRONMENTS

4.1. Basics of radiation effects

4.2. Selection of materials for nuclear power plants

4.3. Effect of irradiation on the mechanical properties

6. Cronograma

6.1. Cronograma de la asignatura *

Sem	Actividad tipo 1	Actividad tipo 2	Tele-enseñanza	Actividades de evaluación
1	Presentation of the subject, Introduction to extreme environments Duración: 02:00 LM: Actividad del tipo Lección Magistral			
2	Metals for extreme-in service operation I Duración: 02:00 LM: Actividad del tipo Lección Magistral			
3	Metals for extreme-in service operation II Duración: 02:00 LM: Actividad del tipo Lección Magistral			
4	Metals for extreme-in service operation III Duración: 02:00 LM: Actividad del tipo Lección Magistral			
5	Composites for extreme in-service applications I Duración: 02:00 LM: Actividad del tipo Lección Magistral			
6	Composites for extreme in-service applications II Duración: 02:00 LM: Actividad del tipo Lección Magistral			
7	Composites for extreme in-service applications III Duración: 02:00 LM: Actividad del tipo Lección Magistral			
8	Introduction to Refractory Ceramic materials Duración: 01:00 LM: Actividad del tipo Lección Magistral			Partial examination 1 ET: Técnica del tipo Prueba Telemática Evaluación Progresiva Presencial Duración: 01:00
9	Refractory ceramic materials 1 Duración: 02:00 LM: Actividad del tipo Lección Magistral			
10	Refractory ceramic materials 2 Duración: 02:00 LM: Actividad del tipo Lección Magistral			
11	Refractory ceramic materials 3 Duración: 02:00 LM: Actividad del tipo Lección Magistral			
12	Refractory ceramic materials 4 Duración: 02:00 INV: Aprendizaje basado en investigación			

13	Materials for low-temperature applications, Superconductor materials I Duración: 02:00 LM: Actividad del tipo Lección Magistral			
14	Materials for low-temperature applications, Superconductor materials II Duración: 02:00 LM: Actividad del tipo Lección Magistral			
15		Materials for low-temperature applications, Superconductors 3 Duración: 02:00 PL: Actividad del tipo Prácticas de Laboratorio		
16	Final Remarks on the subject Duración: 01:00 AC: Actividad del tipo Acciones Cooperativas			Partial examination 2 ET: Técnica del tipo Prueba Telemática Evaluación Progresiva Presencial Duración: 01:00
17				Final regular examination ET: Técnica del tipo Prueba Telemática Evaluación Global Presencial Duración: 02:00 Final extraordinary examination ET: Técnica del tipo Prueba Telemática Evaluación Global Presencial Duración: 02:00

Para el cálculo de los valores totales, se estima que por cada crédito ECTS el alumno dedicará dependiendo del plan de estudios, entre 26 y 27 horas de trabajo presencial y no presencial.

7. Actividades y criterios de evaluación

7.1. Actividades de evaluación de la asignatura

7.1.1. Evaluación (progresiva)

Sem.	Descripción	Modalidad	Tipo	Duración	Peso en la nota	Nota mínima	Competencias evaluadas
8	Partial examination 1	ET: Técnica del tipo Prueba Telemática	Presencial	01:00	50%	5 / 10	CG1 CG7 CE1 CE3 CE4 CE5
16	Partial examination 2	ET: Técnica del tipo Prueba Telemática	Presencial	01:00	50%	5 / 10	CG1 CG7 CE1 CE3 CE4 CE5

7.1.2. Prueba evaluación global

Sem	Descripción	Modalidad	Tipo	Duración	Peso en la nota	Nota mínima	Competencias evaluadas
17	Final regular examination	ET: Técnica del tipo Prueba Telemática	Presencial	02:00	100%	5 / 10	CG1 CG7 CE1 CE3 CE4 CE5
17	Final extraordinary examination	ET: Técnica del tipo Prueba Telemática	Presencial	02:00	100%	5 / 10	

7.1.3. Evaluación convocatoria extraordinaria

Descripción	Modalidad	Tipo	Duración	Peso en la nota	Nota mínima	Competencias evaluadas
Final extraordinary examination	ET: Técnica del tipo Prueba Telemática	Presencial	02:00	100%	5 / 10	CG1 CG7 CE1 CE3 CE4 CE5

7.2. Criterios de evaluación

Within the *PROGRESSIVE EVALUATION* system, the following assignments need to be completed:

1. Attendance and active participation in more than 70% of classes
2. Completion of two written tests, i.e., partial tests, (1 h duration each) regarding the theoretical contents of the Subject. Each partial exam comprises 50% of the total grade.
 - Each partial exam will consist of up to 40 questions equally scored, where each question may have multiple-choice answers. An incorrect answer invalidates the question, even if any correct answer has been marked but does not subtract from other questions. Each correct answer to a question gives a proportionate share of the mark for that question based on the number of correct answers in the questionnaire. The exam will last a maximum of 60 minutes and, although submitted via Moodle, must be completed in class.
 - The contents of the subject included in each partial exam will be considered released if the grade obtained on the exam is higher than 5 out of 10.
- 3.- Proposition of exam-like questions. Each student will propose at least two questions per topic/session. This will add up to 1 point (proportional to the number of questions proposed) to the final grade, only if the Subject is already passed (i.e. total grade higher than 5 over 10).

8. Recursos didácticos

8.1. Recursos didácticos de la asignatura

Nombre	Tipo	Observaciones
Moodle	Recursos web	Moodle platform
Lecture notes	Bibliografía	Lecture Notes available on Moodle
Questions Bank	Recursos web	Students are encouraged to suggest their own Exam Questions in a Moodle database.
Specialized papers	Bibliografía	Specialized scientific and technical articles on the topics covered by the Subject will be provided to students via Moodle
Materials Under Extreme Conditions, Vincenzo Schettino and Roberto Bini, Imperial College Press, winter 2012	Bibliografía	
https://www.northrefractories.com/	Recursos web	
https://www.valoref.com/secondary-raw-materials	Recursos web	
Ceramic Matrix Composites by Chawla K.K. (2019) In: Composite Materials. Springer, Cham.	Bibliografía	
Ultra-High Temperature Ceramics: Materials for Extreme Environment Applications. Editor(s): William G. Fahrenholtz, Eric J. Wuchina, William E. Lee, Yanchun Zhou, 2014, DOI:10.1002/9781118700853	Bibliografía	
Fundamental aspects of and Failure modes in High-Temperature composites (NASA), Christos D. Chamis and Carol A. Ginty, Lewis Research Center Cleveland, Ohio	Bibliografía	

Advances in oxidation and ablation resistance of high and ultra high temperature ceramics modified or coated carbon/carbon composites, Journal of the European Ceramic Society 38 (2018) 1?28	Bibliografía	Journal article
Introduction to Superconductivity (Second Edition) by Michael Tinkham	Bibliografía	For the coverage of basic superconductivity; it is a classic text and covers most completely the topics in the course concerning basic superconductivity
Solid State Physics by Ashcroft and Mermin	Bibliografía	Useful chapters in standard Solid State textbooks:
Bardeen J, Cooper LN, Schrieffer JR. Theory of superconductivity. Phys Rev 1957; 108(5):1175-1204	Bibliografía	Journal Article, i.e. the famous paper that established the "BCS" theory of superconductivity and earned the authors a Nobel Prize
Superconduction.org website	Recursos web	Good explanations of superconductivity and the latest news about room temperature superconductors and other advances in the field
Radiation Effects in Materials	Bibliografía	Monteiro, Waldemar Alfredo, ed. 2016. Radiation Effects in Materials. InTech. doi:10.5772/61498.
Materials for Nuclear Plants	Bibliografía	From Safe Design to Residual Life Assessments; Wolfgang Hoffelner, Springer London, 2012 https://doi.org/10.1007/978-1-4471-2915-8

9. Otra información

9.1. Otra información sobre la asignatura

Although not formally included in the Course Syllabus, this subject will introduce students to national and international policies related to the 2030 Agenda and its 17 accompanying Sustainable Development Goals (SDGs) in a transversal manner, but with special attention to the following SDGs:

1. Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all
2. Achieve gender equality and empower all women and girls.
4. Ensure access to affordable, reliable, sustainable, and modern energy for all
6. Develop resilient infrastructure, promote inclusive and sustainable industrialization, and encourage innovation
9. Ensure sustainable consumption and production patterns
10. Take urgent action to combat climate change and its effects.

Teaching and evaluation activities within the subject will be moved online if necessary for health reasons.