



POLITÉCNICA

INTERNATIONAL
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COORDINATION PROCESS OF
LEARNING ACTIVITIES
PR/CL/001



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

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

45000121 - Properties Of Materials Ii

DEGREE PROGRAMME

04MI - Grado En Ingenieria De Materiales

ACADEMIC YEAR & SEMESTER

2025/26 - Semester 1

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1. Description

1.1. Subject details

Name of the subject	45000121 - Properties Of Materials II
No of credits	6 ECTS
Type	Compulsory
Academic year of the programme	Third year
Semester of tuition	Semester 5
Tuition period	September-January
Tuition languages	English
Degree programme	04MI - Grado en Ingeniería de Materiales
Centre	04 - E.T.S. De Ing. De Caminos Canales Y P.
Academic year	2025-26

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Jose Luis Prieto Martin (Subject coordinator)	ETSIT - A032	joseluis.prieto@upm.es	M - 10:00 - 12:00 Tu - 10:00 - 12:00 W - 10:00 - 12:00

* 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

- Física General
- Magnetismo Básico

4. Skills and learning outcomes *

4.1. Skills to be learned

CE 5. - Capacitar para el aprendizaje autónomo de nuevos conocimientos y técnicas

CG 1 - Uso de la lengua inglesa

CG 11 - Responsabilidad y ética profesional

CG 2 - Capacidad de trabajo en equipo

CG 3 - Comunicación oral y escrita

4.2. Learning outcomes

RA32 - Conocer los principios de funcionamiento y ser capaces de experimentar con dispositivos electrónicos elementales; transistores, láseres y otros sistemas

RA30 - Conocer y saber relacionar dicho comportamiento con la estructura del material a nivel atómico, molecular y macroscópico.

RA31 - Conocer y saber calcular mediante las teorías más relevantes la respuesta electrónica, magnética, térmica y óptica de los materiales.

RA28 - Saber trabajar en equipo. Ejecutar el trabajo con responsabilidad y respeto a los demás.

RA27 - Utilizar con soltura la comunicación oral y escrita en lengua española e inglesa

RA29 - Entender, asimilar y manejar los conceptos básicos que describen el comportamiento electrónico, magnético, térmico y óptico de los materiales.

* 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 goal of this topic is to provide the student with the basic knowledge of the magnetic and thermal properties of most common industrial materials. Magnetic materials have a vital importance in a wide variety of applications at the industrial level, such as computers (hard drives and reading heads, etc.), permanent magnets (motors, actuators, etc.), magnetic shielding, sensors, etc. The student will learn the general concepts required to understand the basis of all the applications mentioned. In parallel, the thermal properties of materials are also fundamental to understand a great number of applications in modern industry. The student will learn the basic concepts governing heat diffusion and the physical properties that lead to the thermal conductivity and heat capacity of different materials. Within the subject of thermal transfer, we will only cover the transfer within materials (diffusion and briefly convection). This is a course on material properties, not on heat transfer on buildings. Therefore, most teaching in thermal

properties, including heat transfer, is treated from the physical and from the material point of view. We do not cover radiation, which is a more specialized subject.

5.2. Syllabus

1. Introduction to Magnetism
 - 1.1. Magnetic Moment, B, H, M vectors
 - 1.2. Sources of Magnetism
 - 1.3. Magnetic Energy
 - 1.4. Magnetic circuit
 - 1.5. Demagnetizing Field
2. Magnetism in the matter
 - 2.1. Paramagnetism
 - 2.2. Ferromagnetism
 - 2.3. Very general concept of Diamagnetism
3. Magnetic Anisotropy
 - 3.1. Magnetocrystalline Anisotropy
 - 3.2. Uniaxial Anisotropy
 - 3.3. Magnetic annealing and plastic deformation
 - 3.4. Shape anisotropy
 - 3.5. Surface Anisotropy
4. Magnetostriction
 - 4.1. Phenomenology
 - 4.2. Anisotropy induced by stress
 - 4.3. Other magnetoelastic effects and devices
5. Magnetic domains
 - 5.1. Origin, types and energy
 - 5.2. Magnetic domain structure
 - 5.3. Magnetization Process and Hysteresis loop

6. Modern Magnetic Materials
 - 6.1. Magnetic Recording
 - 6.2. Introduction to Spintronics
 - 6.3. Permanent Magnets
 - 6.4. Magnetic nanoparticles
7. Introduction to thermal properties
 - 7.1. Kinetic molecular theory
 - 7.2. Boltzmann Statistics
 - 7.3. Equipartition and Equipartition Motion
8. Diffusion
 - 8.1. Heat diffusion and mass transfer
9. Heat transfer Steady State
 - 9.1. Thermal conduction, Convection and Radiation
 - 9.2. Plane Wall
 - 9.3. Insulation and R values
 - 9.4. Cylindrical systems
 - 9.5. Heat Sources
 - 9.6. Multiple dimensions
10. Heat transfer. Unsteady state
 - 10.1. Lumped heat Capacity
 - 10.2. Biot and Fourier Numbers
 - 10.3. Transient Heat flow, plane, sphere and cylinder
 - 10.4. Heisler Charts
11. Heat Capacity in Materials
 - 11.1. Theoretical Models to describe Specific Heat
 - 11.2. Phonons
 - 11.3. Debye theory
 - 11.4. Heat Capacity in metals at low temperatures
12. Thermal conductivity of materials

12.1. Thermal conductivity in materials

12.2. Physical effects limiting the thermal conductivity

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	Presentation (0.2h) Introduction to magnetism (2.5h) Magnetic moment. B,H, M, A fields, Sources of magnetic field. Magnetic energy. Magnetic circuit. Demagnetizing field. Duration: 03:00 Lecture		Problems on general magnetism Duration: 03:00 Problem-solving class	
2	Magnetism of the matter I (2h) Diamagnetism, paramagnetism, ferromagnetism I. Duration: 03:00 Lecture		Problems on Magnetism in the Matter Duration: 02:00 Problem-solving class	
3	Magnetic anisotropy (2h) Magnetocrystalline anisotropy, Uniaxial anisotropy. Induced magnetic anisotropy, magnetic annealing, plastic deformation, shape anisotropy. Duration: 03:00 Lecture		Problems on Magnetic Anisotropy Duration: 02:00 Problem-solving class	
4	Magnetostriction (2h) Phenomenology, mechanism, measurements, anisotropy induced by stresses. Other magneto elastic effects. Magnetoelastic devices Duration: 03:00 Lecture		Problems on Magnetostriction Duration: 02:00 Problem-solving class	
5	Magnetic domains (2h) Origin, types and energy. Magnetic domain structure. Magnetization process. Hysteresis loop. Duration: 02:00 Lecture		Problems on Magnetic Domains Duration: 02:00 Problem-solving class	
6	Lectures on modern Magnetism. (One or two of the following topics) Magnetic recording (2h) Spintronics (2h) Magnetic materials and their applications (2h) Magnetic nanoparticles (2h) Magnetism and biology (2h) Duration: 02:00 Lecture			Partial Exam Written test Progressive assessment Presential Duration: 02:30
7	Introduction to thermal properties. (2h) Kinetic molecular theory and Boltzmann statistics. Equipartition and Bownian motion Duration: 02:00 Lecture		Problems on Thermal Properties, basic concepts Duration: 03:00 Problem-solving class	

8	Diffusion (2h) Heat diffusion and mass transfer Duration: 01:00 Lecture		Problems on diffusion Duration: 01:00 Problem-solving class	
9	Heat Transfer (1.5h). Thermal conduction, Convection and Radiation Steady State conduction. (2h) Plane Wall. Insulation and R values. Cylindrical systems. Heat sources. Multiple dimensions. Duration: 04:00 Lecture		Problems of heat transfer steady state Duration: 03:00 Problem-solving class	
10	Unsteady state. Lumped heat capacity. Biot and Fourier numbers. Transient heat flow, plane, sphere and cylinder. Heisler charts. Duration: 02:00 Lecture		Problems of Heat Transfer Unsteady State Duration: 02:00 Problem-solving class	
11	Lattice vibrations (3h) Specific heat models, the phonon, lattice waves, specific heat Debye theory, thermal conductivity Duration: 02:00 Lecture		Problems on Heat Capacity Duration: 02:00 Problem-solving class	
12	Thermal properties of metals and Free electron model (1h) Heat capacity of conduction electrons, thermal conductivity in metals Duration: 01:00 Lecture		Problems on Thermal Conductivity Duration: 01:00 Problem-solving class	Second Partial Exam Written test Progressive assessment Presential Duration: 02:30
13				Final Exam Written test Global examination Not Presential Duration: 02:30
14				
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
6	Partial Exam	Written test	Face-to-face	02:30	50%	3.5 / 10	CE 5. CG 1 CG 3 CG 11
12	Second Partial Exam	Written test	Face-to-face	02:30	50%	3.5 / 10	CE 5. CG 1 CG 3 CG 11

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
13	Final Exam	Written test	No Presential	02:30	100%	5 / 10	CE 5. CG 1 CG 3 CG 11

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Final exam	Written test	Face-to-face	03:00	100%	5 / 10	CE 5. CG 1 CG 2 CG 3 CG 11

7.2. Assessment criteria

The evaluation would be continuous by default. In the evaluation, we will check if the students have achieved the competences related to the topic. In the continuous evaluation we will use written exams (EX), Individual work (TI) and Group work (TG). For direct evaluation, not following the continuous evaluation, students will have to pass a single written exam in English. This exam will evaluate the same capacities as the continuous evaluations.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Demagnetizing field experiment	Equipment	Showing how the demagnetizing field works
Magnetization process	Equipment	Demonstration of the importance of M in a ferromagnet. Comparative strength with a paramagnet and a diamagnet
Physics of Ferromagnetism	Bibliography	Chikazumy
Magnetism and Magnetic Materials	Bibliography	Jiles
Modern Magnetic Materials	Bibliography	Robert C O'Handley
Introduction to Solid State Physics	Bibliography	Kittel
Solid State Physics	Bibliography	Ashcroft
Heat Transfer	Bibliography	Holman
Concepts in Thermal Physics	Bibliography	Blundell
Solved Problems in thermal and magnetic properties of materials	Bibliography	Jose L. Prieto

9. Other information

9.1. Other information about the subject

In this topic we will cover some examples where the students can visualize the large effect of heat in physical processes and extrapolate to global warming. We will also cover the importance of permanent magnets for generation of energy and fabrication of green vehicles.