ANX-PR/CL/001-01
LEARNING GUIDE

SUBJECT

45000121 - Properties Of Materials Ii

DEGREE PROGRAMME

04MI - Grado En Ingenieria De Materiales

ACADEMIC YEAR & SEMESTER

2021/22 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	45000121 - Properties Of Materials II
No of credits	6 ECTS
Type	Compulsory
Academic year ot the programme	Third year
Semester of tuition	Semester 5
Tuition period	September-January
Tuition languages	English
Degree programme	04MI - Grado en Ingenieria de Materiales
Centre	04 - Escuela Tecnica Superior De Ingenieros De Caminos, Canales Y Puertos
Academic year	2021-22

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 autÃ³nomo de nuevos conocimientos y tÃ©cnicas

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. Permanet Magnets
   6.4. Magnetic nanoparticles
7. Introduction to thermal properties
   7.1. Kinetic molecular theory
   7.2. Boltzmann Statistics
   7.3. Equipartition and Bownian 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. Lumpled 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	Face-to-face classroom activities	Face-to-face laboratory 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	**Problem Solving** Online test Continuous assessment Not Presential Duration: 01:00
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	**Problem Solving** Online test Continuous assessment Not Presential Duration: 01:00
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 Continuous 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	**Essay and public presentation of the essay** Group presentation Continuous assessment Presential Duration: 02:00
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	**Problem Solving** Online test Continuous assessment Not Presential Duration: 01:00
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	**Problem Solving** Online test Continuous assessment Not Presential Duration: 01:00
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 Continuous assessment Presential Duration: 02:30
13				**Final Exam** Written test Final 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.

* 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. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	Problem Solving	Online test	No Presential	01:00	2.5%	3 / 10	CG 11 CE 5. CG 1 CG 3
5	Problem Solving	Online test	No Presential	01:00	2.5%	3 / 10	CG 11 CE 5. CG 1 CG 3
6	Partial Exam	Written test	Face-to-face	02:30	35%	3.5 / 10	CG 11 CE 5. CG 1 CG 3
8	Essay and public presentation of the essay	Group presentation	Face-to-face	02:00	20%	5 / 10	CG 11 CE 5. CG 1 CG 2 CG 3
9	Problem Solving	Online test	No Presential	01:00	2.5%	3 / 10	CG 11 CE 5. CG 1 CG 3
11	Problem Solving	Online test	No Presential	01:00	2.5%	3 / 10	CG 11 CE 5. CG 1 CG 3
12	Second Partial Exam	Written test	Face-to-face	02:30	35%	3 / 10	CG 11 CE 5. CG 1 CG 3

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills

13	Final Exam	Written test	No Presential	02:30	100%	5 / 10	CG 11 CE 5. CG 1 CG 3

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

The evaluation would be continuous by default. Students may choose to renounce to the continuous evaluation but they have to inform the teacher by email within the first 4 weeks of the course using Moodle (not a direct email). 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), Group work (TG) and individual presentations (PI). 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 except the ones related to oral presentations, competences related to the ability to communicate well orally in English.

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