Course guide
220092 - CM - Materials Science

Last modified: 29/06/2023

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 702 - CEM - Department of Materials Science and Engineering.

Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: VERA C. DE REDONDO REALINHO

Others: Farayde Matta Fakhouri
María del Pilar Castejón
Khalil Tafzi El Hadri
María Del Pilar Casas Carné

PRIOR SKILLS

It is recommended having achieved successfully the chemistry and / or physics of the first and second semester in order to fully appreciate the content of the Materials Sciences course.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE09-INDUS. Knowledge of the fundamentals of science, technology, and material chemistry. Understanding the relationship between microstructure, synthesis or processing, and material properties. (Common module for industrial engineering)

Transversal:
CT02 N2. Sustainability and social commitment - Level 2. Applying sustainability criteria and professional codes of conduct in the design and assessment of technological solutions.

TEACHING METHODOLOGY

- Presentation of course contents.
- Sessions of problems.
- Practice sessions.
- Personal implication and exercise series.

In the sessions of content presentation, the teacher will introduce the theoretical basis of matter, concepts, methods and results illustrated with suitable examples to facilitate understanding.
During problem sessions, the teacher will guide students in applying theoretical concepts to solve problems, based on constant critical thinking. Exercises will be proposed and solved by students, thus acquiring the skill in handling of necessary tools in order to resolve problems.
Practice sessions related to course content will be followed in a matter to reinforce key concepts.
Students should study independently to absorb and fix the concepts, solving exercises and prepare reports on practices.

LEARNING OBJECTIVES OF THE SUBJECT

-Provide the basic concepts of Materials Sciences and terminology, encouraging the formal expression interest in the issues dealt in the subject.
- To introduce the students to the different types of materials applied to engineering, from knowledge of composition to structure and properties. It will also be introduced the basic concepts related to the behaviour of materials in service.
- Introduce students to the mechanisms that alter the structure of materials, with or without modification of chemical composition, and establish relationships between structure and properties, which can sometimes be determined empirically or by tests that provide comparative information presented on the response to different actions.
- Consider material selection criteria based on their response or its characteristics.

STUDY LOAD

Type	Hours	Percentage
Hours large group	32,0	21.33
Hours small group	14,0	9.33
Hours medium group	14,0	9.33
Self study	90,0	60.00

Total learning time: 150 h

CONTENTS

1: Introduction to Materials Sciences and Engineering

Description:
1.1. Materials and Engineering
1.2. Historical perspective
1.3. Types of materials. Structural materials. Functional Materials

Related activities:
Theoretical lectures.

Full-or-part-time: 3h
Theory classes: 1h
Self study : 2h

2: Structure of Crystaline solids

Description:
2.1. Crystal systems and Bravais lattices
2.2. Main crystalline structures of metals
2.3. Positions, directions and planes in unit cells
2.4. Comparison between crystal structures FCC, HCP and BCC
2.5. Calculations of density and atomic packing factor
2.6. Polymorphism or Allotropy
2.7. Isotropy and anisotropy
2.8. Crystalline defects

Related activities:
Theoretical lectures.
Sessions of problems solving and case studies.
Activity 1: Practice of crystalline structures.

Full-or-part-time: 18h
Theory classes: 4h
Practical classes: 2h
Laboratory classes: 2h
Self study : 10h

3: Solidification and Diffusion in Solids

Description:
3.1. Solidification of metals
3.2. Metallic solid solutions
3.3. Types of atomic diffusion in solids and Fick's Laws
3.4. Parameters affecting the diffusion in solids
3.5. Industrial applications of diffusion processes

Related activities:
Theoretical lectures.
Sessions of problems solving and case studies.

Full-or-part-time: 16h
Theory classes: 4h
Practical classes: 2h
Self study : 10h

4: Equilibrium Phase Diagrams

Description:
4.1. Equilibrium phase diagrams of pure substances
4.2. Phase rule of Gibbs
4.3. Isomorphous binary alloy systems
4.4. The lever rule
4.5. Invariant reactions
4.6. Eutectic and eutectoid ninary alloy systems
4.7. Peritectic alloy binary systems
4.8. Phase diagrams and intermediate compounds
4.9. Nonequilibrium solidification of alloys

Related activities:
Theoretical lectures.
Sessions of problems solving and case studies.
Activity 2: Practice of Phase Diagrams

Full-or-part-time: 23h
Theory classes: 5h
Practical classes: 2h
Laboratory classes: 2h
Self study : 14h

5: Metal Alloys

Description:
5.1. Iron and steel.
5.2. Phase diagram of iron - iron carbide.
5.3. Common heat treatments of carbon steel.
5.4. Cast irons.
5.5. Non-ferrous alloys.

Related activities:
Theoretical lectures.
Sessions of problems solving and case studies.
Activity 3: Practice of Metallography

Full-or-part-time: 17h
Theory classes: 3h
Practical classes: 2h
Laboratory classes: 2h
Self study : 10h

6: Mechanical Properties of Materials

Description:
6.2. Tensile testing and stress - strain curves.
6.3. Mechanisms of plastic deformation.
6.4. Strengthening mechanisms of metals.
6.5. Toughness and hardness testing.
6.6. Brittle and ductile fracture.

Related activities:
Theoretical lectures.
Sessions of problems solving and case studies.
Activity 4: Practice of tensile test

Full-or-part-time: 18h
Theory classes: 4h
Practical classes: 2h
Laboratory classes: 2h
Self study : 10h

7: Ceramics and Glass

Description:
7.1. Crystal structures of simple ionic ceramics.
7.2. Silicate structure.
7.3. Common and engineering ceramics.
7.4. Electrical properties of ceramics.
7.5. Mechanical properties of ceramics.
7.6. Thermal properties of ceramics.
7.7. Glasses.

Related activities:
Theoretical lectures.
Sessions of problems solving and case studies.
Activity 5: Practice of Thermal Shock

Full-or-part-time: 13h
Theory classes: 3h
Laboratory classes: 2h
Self study : 8h

8: Polymeric Materials

Description:
8.1. Definition and Classification.
8.2. Polymerization reactions.
8.3. Molecular architecture of polymers.
8.4. Crystallinity and stereoisomerism.
8.5. Thermoplastics, thermosets and elastomers.

Related activities:
Theoretical lectures.
Sessions of problems solving and case studies.
Activity 6: Practice for the Identification of Polymer Materials.

Full-or-part-time: 17h
Theory classes: 3h
Practical classes: 2h
Laboratory classes: 2h
Self study : 10h

9: Composite Materials

Description:
9.1. Definition of composite material.
9.2. Classification of composite materials.
9.3. Basic components: matrix and reinforcement.
9.4. Reinforcement.
9.5. Mechanical properties of composite materials.
9.6. Metal matrix composites.
9.7. Ceramic matrix composite materials.
9.8. Polymer matrix composite materials.

Related activities:
Theoretical lectures.
Sessions of problems solving and case studies.
Activity 7: Practice of Laminate Processing

Full-or-part-time: 15h
Theory classes: 2h
Practical classes: 2h
Laboratory classes: 2h
Self study : 9h

10: Functional Materials

Description:
10.1. Materials with electrical and electronic applications.
10.2. Materials for magnetic applications.
10.3. Materials with optical applications.
10.4. Biomaterials.

Related activities:
Theoretical lectures.

Full-or-part-time: 10h
Theory classes: 3h
Self study : 7h

ACTIVITIES

ACTIVITY 1: PRACTICE OF CRYSTAL STRUCTURES

Description:
Practice where the student will work on the concepts of crystal structures.

Specific objectives:
- Understand the concept of periodic order in solids.
- Know how to differentiate the different crystal structures, as well as, understand the concepts of crystal lattice, positions, directions, planes and angles.
- Understand and use the concepts of density, atomic packing, polymorphism, isotropy and anisotropy.

Material:
Practice script, class notes and recommended bibliography.

Delivery:
Practice report.

Full-or-part-time: 5h 45m
Laboratory classes: 2h
Self study: 3h 45m

ACTIVITY 2: PRACTICE OF PHASE DIAGRAMS

Description:
Practical to work on the concepts of equilibrium diagrams of the most common metal alloys, as complement and intensification of contents explained in class.

Specific objectives:
- Introduce students to the interpretation of phase equilibrium diagrams, through the study of common binary alloys.
- Learn to identify the present phases, their composition, relative percentages and resulting microstructure during cooling of alloys.

Material:
Practice script, class notes and recommended bibliography.

Delivery:
Report practice.

Full-or-part-time: 6h 10m
Laboratory classes: 2h
Self study: 4h 10m

ACTIVITY 3: PRACTICAL OF METALLOGRAPHY

Description:
Practice session where the student will learn to prepare metallography probes and observe the microstructures of different materials by optical microscopy.

Specific objectives:
-Learn how to prepare metallographically probes.
-Learn how to use the microscope.
-Know how to identify microstructures.

Material:
Practice script, class notes and recommended bibliography.

Delivery:
Lab report.

Full-or-part-time: 5h 45m
Laboratory classes: 2h
Self study: 3h 45m

ACTIVITY 4: PRACTICE TENSILE TEST

Description:
This session will perform tensile tests with different polymer materials probes and consider external effect such as temperature and strain rate on mechanical properties.

Specific objectives:
- Use a mechanical test machine.
- Understanding the mechanical behaviour of polymers.
- Determine the influence of different parameters in a tensile test.

Material:
Practice script, class notes and recommended bibliography.

Delivery:
Lab report.

Full-or-part-time: 6h 10m
Laboratory classes: 2h
Self study: 4h 10m

ACTIVITY 5: PRACTICE OF THERMAL SHOCK

Description:
After heating at different temperatures and sudden cooling, it is possible to identify and quantify the sensitivity of ceramic materials to temperature changes and the effect it has on their behaviour in service.

Specific objectives:
- Learn what is a ceramic heat shock.
- Know how to evaluate the thermal shock in ceramics.
- Data analysis and presentation of results.

Material:
Practice script, class notes and recommended bibliography.

Delivery:
Lab report.

Full-or-part-time: 5h 45m
Laboratory classes: 2h
Self study: 3h 45m

ACTIVITY 6: PRACTICE OF POLYMERIC MATERIAL IDENTIFICATION

Description:
Identify different families of commonly used polymers.
Notions are provided methods for identifying functional groups of polymers by infra-red spectroscopy Fourier Transform (FT-IR).

Specific objectives:
-Learn what are the main families of thermoplastics.
- Be able to identify commonly used thermoplastics according to their response to the flame.
- Meet other analytical techniques for identification.

Material:
Practice script, class notes and recommended bibliography.

Delivery:
Lab report.

Full-or-part-time: 6h 10m
Laboratory classes: 2h
Self study: 4h 10m

ACTIVITY 7: PRACTICE OF PRODUCING A LAMINATE

Description:
From basic elements (thermoset matrix and reinforcement) is made a component of composite material (laminated), thus displaying the most relevant aspects of the production process and considering the effect of key parameters.

Specific objectives:
- Become familiar with the process of polymerization.
- Learn about a type of composite material.
- Evaluate the effectiveness of reinforcement.

Material:
Practice script, class notes and recommended bibliography.

Delivery:
Lab report.

Full-or-part-time: 5h 45m
Laboratory classes: 2h
Self study: 3h 45m

ACTIVITAT 8: FIRST TEST

Description:
Written test in which the student must show attainment of the knowledge acquired in class.

Specific objectives:
Develop the knowledge acquired in theoretical and practical lectures and show the level of achievement.

Delivery:
Written test

Full-or-part-time: 2h
Theory classes: 2h

ACTIVITY 9: SECOND TEST

Description:
Written test in which the student must show attainment of the knowledge acquired in class.

Specific objectives:
Develop the knowledge acquired in theoretical and practical lectures and show the level of achievement.

Delivery:
Written test

Full-or-part-time: 2h
Theory classes: 2h

THEORY/LARGE GROUPS SESSIONS

Description:
Preparation before and after the theory sessions and attendance.

Specific objectives:
Transfer the necessary knowledge for a correct interpretation of the contents in the large group sessions, resolving doubts about the content of the course and generic skills development.

Material:
Notes posted to the Atenea platform.
General literature of the course.

Delivery:
During some sessions, exercises will be conducted in the class, individually or in small groups.

Full-or-part-time: 70h 30m
Theory classes: 28h
Self study: 42h 30m

EXERCISES/MEDIUM GROUPS SESSIONS

Description:
Preparation before and after the exercises sessions and attendance to the sessions.

Specific objectives:
Acquire the necessary skills for a correct interpretation of the problems of the course, and their satisfactory resolution.
Preparation for the practical part of exams of the course. Development of generic skills.

Material:
Notes posted to the Atenea platform.
General literature of the course.
Exercises on the Atenea platform.

Delivery:
During these sessions, exercises will be conducted in class or virtually, individually or in small groups.

Full-or-part-time: 34h
Practical classes: 14h
Self study: 20h

GRADING SYSTEM

- First test: 42.5%
- Second test: 42.5%
- Practice sessions: 15%

Students will have an opportunity, at final exam schedule, to do an exam that will contain the syllabus of the first partial to be recovered, in addition to another exam with the syllabus of the
second partial The recovered grade will replace the previous one if it is higher.

BIBLIOGRAPHY

Basic:

- Smith, William F. Fundamentos de la ciencia e ingeniería de materiales [on line]. 5a ed. México: McGraw-Hill, 2014 [Consultation: 14/09/2022]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=5732.
- Callister, William D.; Rethwisch, David G. Ciencia e ingeniería de materiales [on line]. 2a ed. Barcelona: Reverté, 2018 [Consultation: 08/03/2023]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=9589. ISBN 9788429195491.
- Shackelford, James F. Introducción a la ciencia de materiales para ingenieros [on line]. 7a ed. Madrid: Pearson Educación, 2010 [Consultation: 19/09/2022]. Available on: https://www-ingebook-com.recursos.biblioteca.upc.edu/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=1258. ISBN 9788483229606.
- Askeland, Donald R. Ciencia e ingeniería de los materiales. Madrid: International Thomson Editores, 2001. ISBN 8497320166.

Complementary:

- Ashby, Michael F. Materiales para ingenieria, vol. 1, Introducción a las propiedades, las aplicaciones y el diseño introducción a las propiedades, las aplicaciones y el diseño [on line]. Barcelona: Reverté, 2008 [Consultation: 20/09/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5635457. ISBN 9788429172553.
- Saja, José Antonio de [et al.]. Materiales : estructura, propiedades y aplicaciones. Madrid: Thomson, 2005. ISBN 8497323467.
- Barroso, Segundo; Ibáñez, Joaquín. Introducción al conocimiento de materiales [on line]. Madrid: Universidad Nacional de Educación a Distancia, 2014 [Consultation: 18/04/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=3219230. ISBN 8436268598.
- John, V. B. Ingeniería de materiales : cuadernos de trabajo. Wilmington: Addison-Wesley Iberoamericana, 1994. ISBN 0201601451.
- Cabrera, J. M. [et al.]. Materiales en ingeniería : problemas resueltos. 2a ed. Barcelona: Edicions UPC, 2002. ISBN 9701507746.
- Barroso, Segundo. Construcción e interpretación de diagramas de fase binarios. Madrid: Universidad Nacional de Educación a Distancia, 1998.
- Casanovas Salas, Jordi. Introducción a la Ciencia de los Materiales. Barcelona: Cálamo, 2002. ISBN 8495860112.