Course guides
220092 - CM - Materials Science

Last modified: 22/04/2021

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: 2021 ECTS Credits: 6.0 Languages: Catalan, Spanish

LECTURER

Coordinating lecturer: VERA C. DE REDONDO REALINHO
Others: DAVID ARENCÓN OSUNA

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:
1. An understanding of the fundamentals of science, technology and materials chemistry, as well as the relationship between microstructure, synthesis and processing and the properties of materials.

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours medium group</td>
<td>14.0</td>
<td>9.33</td>
</tr>
<tr>
<td>Hours small group</td>
<td>14.0</td>
<td>9.33</td>
</tr>
<tr>
<td>Hours large group</td>
<td>32.0</td>
<td>21.33</td>
</tr>
<tr>
<td>Self study</td>
<td>90.0</td>
<td>60.00</td>
</tr>
</tbody>
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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: 4h 30m  
Theory classes: 2h  
Self study : 2h 30m

2: Structure of Crystaline solids and Defects

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. Crystal defects

Related activities:  
Theoretical lectures.  
Sessions of problems solving and case studies.  
Activity 1: Practice of crystal 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: 14h
Theory classes: 4h
Practical classes: 2h
Self study: 8h

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 binary 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: 22h 30m
Theory classes: 5h
Practical classes: 2h
Laboratory classes: 2h
Self study: 13h 30m
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. Low alloy steels.
5.5. Stainless steels.
5.6. Cast irons.
5.7. Aluminum alloys.
5.8. Copper alloys.
5.9. Other alloys.

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

**Full-or-part-time:** 18h
Theory classes: 4h
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.

**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 30m
Theory classes: 3h
Laboratory classes: 2h
Self study : 8h 30m

8: Polymeric Materials

Description:
8.1. Definition and Classification.
8.2. Polymerization reactions.
8.3. Industrial methods of polymerization.
8.4. Molecular architecture of polymers.
8.5. Crystallinity and stereoisomerism.
8.6. Mechanical Properties of 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: 18h
Theory classes: 4h
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.
9.7. Ceramic matrix composite materials.

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

### Full-or-part-time: 13h 30m
- Theory classes: 2h
- Practical classes: 2h
- Laboratory classes: 2h
- Self study: 7h 30m

## 10: Functional Materials

### Description:
10.2. Materials for magnetic applications.
10.3. Materials with optical applications.
10.4. Biomaterials.

### Related activities:
Activity 8: Supervised work, description of a functional material.

### Full-or-part-time: 10h
- Self study: 10h
### 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 through the basics of networks and structures crystal.
- Learn to distinguish the different crystal structures and understand the concepts of crystal lattice positions, directions, plans and angles.
- Understand and manage the concepts of density, packing, polymorphism, isotropy and anisotropy.

**Material:**
Practice script, class notes and recommended bibliography.

**Delivery:**
Delivery of the corresponding lab report.

**Full-or-part-time:** 4h 30m
Laboratory classes: 2h
Self study: 2h 30m

### 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:** 4h 30m
Laboratory classes: 2h
Self study: 2h 30m
### 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:** 4h 30m  
Laboratory classes: 2h  
Self study: 2h 30m

### 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:** 4h 30m  
Laboratory classes: 2h  
Self study: 2h 30m
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: 4h 30m
Laboratory classes: 2h
Self study: 2h 30m

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: 4h 30m
Laboratory classes: 2h
Self study: 2h 30m
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: 4h 30m
Laboratory classes: 2h
Self study: 2h 30m

ACTIVITY 8: WORKING ON A FUNCTIONAL MATERIAL

Description:
The students will work on a functional material, explaining their characteristics, properties, preparation methods and applications.

Specific objectives:
- Learn functional materials of uncommon application.

Material:
Recommended bibliography.

Delivery:
Written work and oral presentation.

Full-or-part-time: 10h
Self study: 10h

ACTIVITAT 9: 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 10: 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: 40%
- Second test: 40%
- Practice sessions: 10%
- Work about a functional material: 10%

The students with notes lower than 5 obtained in the first test, will have the option to recover the day of the final exam in the same time zone. The mark obtained with this recovery of the first partial will replace the previous note if it is superior.

BIBLIOGRAPHY

Basic:

Complementary: