220092 - Materials Science

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 702 - CMEM - Department of Materials Science and Metallurgy
Academic year: 2019
Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 6 Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: SILVIA ILLESCAS FERNÁNDEZ

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 service behaviour, durability and materials recycling.
- 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 and to introduce different industrial processing of materials manufacturing techniques of final components.

### Study load

<table>
<thead>
<tr>
<th></th>
<th>Hours large group:</th>
<th>Hours medium group:</th>
<th>Hours small group:</th>
<th>Guided activities:</th>
<th>Self study:</th>
</tr>
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<tbody>
<tr>
<td><strong>Total learning time:</strong></td>
<td>150h</td>
<td>32h</td>
<td>14h</td>
<td>14h</td>
<td>90h</td>
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<td>21.33%</td>
<td>9.33%</td>
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</table>
# 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.

## Learning time:
- Theory classes: 2h
- Self study: 2h 30m

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# 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.

## Learning time:
- 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.

**Learning 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 system
- 4.4. The lever rule
- 4.5. Invariant reactions
- 4.6. Eutectic alloy system and binary eutectoid
- 4.7. Peritectic alloy systems and binary peritectoides
- 4.8. Phase diagrams and intermediate compounds
- 4.9. Ternary phase diagrams
- 4.10. Solidification of nonequilibrium alloys

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

**Learning 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.
- 5.4. Low alloy steels.
- 5.5. Stainless steels.
- 5.6. Cast irons.
- 5.7. Aluminum alloys.
- 5.8. Copper alloys.
- 5.9. Other alloys (magnesium, titanium and nickel).
- 5.10. Forming processes.

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

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.
- 6.7. Fatigue.

**Related activities:**
Theoretical lectures.
Sessions of problems solving and case studies.
Activity 4: Practice of tensile test
## 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. Crystals.
- 7.8. Ceramic processing.

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

### Learning time:
- 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.
- 8.5. Crystallinity and stereoisomerism.
- 8.7. Processing of plastic materials.

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

### Learning time:
- Theory classes: 4h
- Practical classes: 2h
- Laboratory classes: 2h
- Self study: 10h
## 9: Composite Materials

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

### Description:
- 9.1. Definition of composite material.
- 9.2. Classification of composite materials.
- 9.4. Reinforcement.
- 9.5. Mechanical properties of composite materials.

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

## 10: Functional Materials

### Learning time: 10h
- Self study: 10h

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

| ACTIVITY 1: PRACTICE OF CRYSTAL STRUCTURES | Hours: 4h 30m  
Laboratory classes: 2h  
Self study: 2h 30m |
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<tr>
<td><strong>Description:</strong></td>
<td>Practice where the student will work on the concepts of crystal structures.</td>
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<tr>
<td><strong>Support materials:</strong></td>
<td>Practice script, class notes and recommended bibliography.</td>
</tr>
<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
<td>Delivery of the corresponding lab report.</td>
</tr>
</tbody>
</table>
| **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. |

| ACTIVITY 2: PRACTICE OF PHASE DIAGRAMS | Hours: 4h 30m  
Laboratory classes: 2h  
Self study: 2h 30m |
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<tr>
<td><strong>Description:</strong></td>
<td>Practical to work on the concepts of equilibrium diagrams of the most common metal alloys, as complement and intensification of contents explained in class.</td>
</tr>
<tr>
<td><strong>Support materials:</strong></td>
<td>Practice script, class notes and recommended bibliography.</td>
</tr>
<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
<td>Report practice.</td>
</tr>
</tbody>
</table>
| **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. |

| ACTIVITY 3: PRACTICAL OF METALLOGRAPHY | Hours: 4h 30m  
Laboratory classes: 2h  
Self study: 2h 30m |
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Practice session where the student will learn to prepare metallography probes and observe the microstructures of different materials by optical microscopy.</td>
</tr>
<tr>
<td><strong>Support materials:</strong></td>
<td>Practice script, class notes and recommended bibliography.</td>
</tr>
<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
<td>Lab report.</td>
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**Specific objectives:**
- Learn how to prepare metallographically probes.
- Learn how to use the microscope.
- Know how to identify microstructures.

### ACTIVITY 4: PRACTICE TENSILE TEST

<table>
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<th>Hours: 4h 30m</th>
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<tr>
<td>Laboratory classes: 2h</td>
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<tr>
<td>Self study: 2h 30m</td>
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**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.

**Support materials:**
Practice script, class notes and recommended bibliography.

**Descriptions of the assignments due and their relation to the assessment:**
Lab report.

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

### ACTIVITY 5: PRACTICE OF THERMAL SHOCK

<table>
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<th>Hours: 4h 30m</th>
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<tr>
<td>Laboratory classes: 2h</td>
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<tr>
<td>Self study: 2h 30m</td>
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**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.

**Support materials:**
Practice script, class notes and recommended bibliography.

**Descriptions of the assignments due and their relation to the assessment:**
Lab report.

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

### ACTIVITY 6: PRACTICE OF POLYMERIC MATERIAL IDENTIFICATION

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<th>Hours: 4h 30m</th>
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<tr>
<td>Laboratory classes: 2h</td>
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<tr>
<td>Self study: 2h 30m</td>
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### 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).

### Support materials:
- Practice script, class notes and recommended bibliography.

### Description of the assignments due and their relation to the assessment:
- Lab report.

### 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.

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### Activity 7: Practice of Producing a Laminate

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<th>Hours</th>
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<tr>
<td>4h 30m</td>
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<tr>
<td>Laboratory classes: 2h</td>
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<tr>
<td>Self study: 2h 30m</td>
</tr>
</tbody>
</table>

**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.

**Support materials:**
- Practice script, class notes and recommended bibliography.

**Description of the assignments due and their relation to the assessment:**
- Lab report.

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

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### Activity 8: Working on a Functional Material

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<th>Hours</th>
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<tr>
<td>10h</td>
</tr>
<tr>
<td>Self study: 10h</td>
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**Description:**
- The students will work on a functional material, explaining their characteristics, properties, preparation methods and applications.

**Support materials:**
- Recommended bibliography.

**Description of the assignments due and their relation to the assessment:**
- Written work and oral presentation.

**Specific objectives:**
- Learn functional materials of uncommon application.
### ACTIVITAT 9: FIRST TEST

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

**Descriptions of the assignments due and their relation to the assessment:**
Written test

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

**Hours:** 2h
- Theory classes: 2h

### ACTIVITY 10: SECOND TEST

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

**Descriptions of the assignments due and their relation to the assessment:**
Written test

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

**Hours:** 2h
- Theory classes: 2h

### THEORY/ LARGE GROUPS SESSIONS

**Hours:** 70h 30m
- Theory classes: 28h
- Self study: 42h 30m

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

**Support materials:**
- Notes posted to the Atenea platform.
- General literature of the course.

**Descriptions of the assignments due and their relation to the assessment:**
During some sessions, exercises will be conducted in the class, individually or in small groups.

**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.

### EXERCISES/ MEDIUM GROUPS SESSIONS

**Hours:** 34h
- Practical classes: 14h
- Self study: 20h

**Description:**
Preparation before and after the exercises sessions and attendance to the sessions.
Support materials:
- Notes posted to the Atenea platform.
- General literature of the course.
- Exercises on the Atenea platform.

Descriptions of the assignments due and their relation to the assessment:
- During these sessions, exercises will be conducted in class or virtually, individually or in small groups.

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.

Qualification 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.
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Bibliography

Basic:


Complementary:


