Course guide
240751 - 240751 - Science and Technology of Materials

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 702 - CEM - Department of Materials Science and Engineering.
Degree: BACHELOR’S DEGREE IN INDUSTRIAL TECHNOLOGIES AND ECONOMIC ANALYSIS (Syllabus 2018).
(Compulsory subject).
Academic year: 2022 ECTS Credits: 6.0 Languages: English

LECTURER

Coordinating lecturer: Alca Cabrelles, Jorge
Others:

PRIOR SKILLS

Basic knowledge of density calculations in cubic crystals
Basic knowledge of cubic and hexagonal crystal structures including atomic packing factor calculations.

TEACHING METHODOLOGY

Master classes, video recordings.

LEARNING OBJECTIVES OF THE SUBJECT

To gain a basic knowledge of metallic, ceramic and polymeric materials.
To comprehend the interrelationship between microstructure and mechanical properties. Mechanical property tailoring.
To understand crystalline defects and microstructural development of metals.
To gain basic knowledge of the mechanical behavior of materials and associated testing procedures.
To use phase diagrams in understanding microstructural development of metals and ceramics.
Basic material processing routes.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Self study</td>
<td>90,0</td>
<td>60.00</td>
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<tr>
<td>Hours small group</td>
<td>6,0</td>
<td>4.00</td>
</tr>
<tr>
<td>Hours large group</td>
<td>54,0</td>
<td>36.00</td>
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</tbody>
</table>

Total learning time: 150 h
### CONTENTS

#### Introduction

**Description:**
Material families and bondings

**Specific objectives:**
- Ionic, metallic and secondary bondings. Electronegativity calculation.
- Atomic bonding, bonding energies and basic knowledge of atomic potentials.
- Relationship between the bonding energy, the elastic stiffness and the melting temperature.
- Intensive vs. extensive material properties.

**Full-or-part-time:** 1h 30m  
Theory classes: 1h 30m

#### Crystalline structures in metals and ceramics

**Description:**
Basic understanding of crystalline structures in metals and ceramics. Crystalline vs amorphous structures

**Specific objectives:**
- Different face-centered cubic (FCC), body-centered cubic (BCC) and hexagonal closed-packed (HCP) structures in metals.  
- Miller indices for planes and directions in the cubic system. Normality rule.  
- Density and planar density calculations.  
- Structures of ionic crystals. Cation to anion ratio and the resulting constructive units.  
- Silicate structures  
- Glass transition vs. melting temperature  
- Glass modifiers  
- Viscosity vs. density plots and their use in glass processing.

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

#### Crystalline defects

**Description:**
Vacancies, dislocations, grain boundaries and free surfaces

**Specific objectives:**
- Point defects (Vacancies and self-interstitials). Maxwell-Boltzman statistics and Arrhenius-type relations.  
- Vacancy density calculations and thermal-independent activation energies.  
- Tetrahedral and octahedral sites in FCC and BCC cells.  
- Grain boundaries: Low-angle grain boundaries and the Read-Shockley model. Generic grain boundaries, misorientation angle and grain boundary energy.  
- Thermally-activated grain growth and grain growth kinetics. Apex angles in grain boundaries.  
- Free surfaces and atomistic descriptions. Free surface energy.

**Full-or-part-time:** 6h  
Theory classes: 6h
Solid state diffusion

**Description:**
Diffusion laws and atomic flux in materials

**Specific objectives:**
- Interstitial and substitutional (vacancy) diffusion.
- Influence of crystal structure, density and melting temperature on diffusion.
- Second Fick's law and non-steady state diffusion.
- Characteristic mathematical solutions for non-steady state diffusion.

**Full-or-part-time:** 3h
Theory classes: 3h

Phase diagrams and microstructures of metallic alloys

**Description:**
Introduction to binary phase diagrams and their use in predicting microstructures of key metallic materials and alloys.

**Specific objectives:**
- Eutectic diagram and non-equilibrium solidification. Dendrite formation in cast metals.
- Allotropic transformations.
- Peritectic, peritectoid and eutectoid reactions.
- Phase diagrams in steels, aluminum alloys, brass, bronze. Microstructural features.

**Full-or-part-time:** 10h
Theory classes: 10h

Polymers

**Description:**
Introduction to polymeric materials. Thermoplastics, thermosets and elastomers

**Specific objectives:**
- Monomers and repeat units. Polymeric chains, mean molecular weight.
- Copolymers.
- Polymer reactions and polymerization methods.
- Branched, cross-linked and network polymers.
- Polymer crystallinity and defects.
- Glass transition and melting temperatures in polymers.
- States of macromolecular aggregation.

**Full-or-part-time:** 4h
Theory classes: 4h
### Mechanical behavior of Materials

**Description:**
Elastic and plastic responses of metals, ceramics and polymers

**Specific objectives:**
- Elasticity in metals and ceramics. Rubber elasticity
- Plasticity in metals. The stress-strain curve and its measurement. Associated mechanical properties.
- Strain hardening and dislocation interactions.
- Hardness measurements. Correlation between hardness and the uniaxial stress-strain curve.
- Microstructural tailoring of metals and the prediction of the yield strength in engineering microstructures. Mechanical properties of steels
- Plastic deformation in materials processing.
- Fracture and fatigue in metals.
- Creep and creep mechanisms in metals.
- Mechanical properties of polymeric materials.

**Full-or-part-time:** 12h

**Theory classes:** 12h

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### GRADING SYSTEM

One intermediate examen (E1) and one final exam. The final exam is comprised of three tests: The first is a theory examen (T), the second is a numerical exam comprising a set of problems (P), the third is a laboratory exam based on the laboratory activities of the course (L).

If the grade of the final exam is higher than that of the intermediate exam, then the final grade, FG, is obtained as:

\[ FG = 0.60 \cdot T + 0.25 \cdot P + 0.15 \cdot L \]

If the grade of the final exam is smaller than that of the partial exam, then the final grade, FG, is obtained as:

\[ FG = 0.35 \cdot E1 + 0.35 \cdot T + 0.15 \cdot P + 0.15 \cdot L \]