

## 340096 - CIMA-D4002 - Materials Science

Coordinating unit:	340 - EPSEVG - Vilanova i la Geltrú School of Engineering
Teaching unit:	702 - CMEM - Department of Materials Science and Metallurgy
Academic year:	2017
Degree:	BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits:	6
Teaching languages:	Catalan, Spanish

### Teaching staff

Coordinator:	M TERESA BAILE PUIG
Others:	M. TERESA BAILE PUIG - JOSEP ANTON PICAS BARRACHINA

### Degree competences to which the subject contributes

#### Specific:

1. CE9. Basic knowledge of science, technology and material chemistry. Understand relation between microstructure, synthesis or processing and material properties.
2. CE25. Knowledge and ability to apply material engineering.

#### Transversal:

3. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.
4. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.
5. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
6. EFFECTIVE USE OF INFORMATION RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.

### Teaching methodology

In the theory classes the basic concepts of the subject will be explained. In the classes of problems the basic techniques for the resolution of problems will be explained and the proposed problems will be discussed, from the student's contributions. In the practical exercises will explain the basic knowledge to perform the different proposed tests and the obtained results will be interpreted and discussed.

In the out-class activities the professor supervises the student's work by means of the analysis of his evolution through the evaluation activity and the guided activities.

### Learning objectives of the subject

1. Understand and contrast the fundamental concepts of crystalline structure and microstructure of the different types of materials
2. Select the chemical/physical/mechanical magnitudes of the materials necessities in accordance with the specifications of a product.
3. Understand the relation between the microstructure, the processing and the materials properties.
4. Know the effect the material microstructure in its mechanical, electrical and magnetic behavior.

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5. Select of materials based on their chemical, thermal, electrical, magnetic and mechanical properties
6. Applies the standards of tests.
7. Be able to adapt to the new technologies and new materials.

### Study load

Total learning time: 150h	Hours large group:	30h	20.00%
	Hours medium group:	0h	0.00%
	Hours small group:	30h	20.00%
	Guided activities:	0h	0.00%
	Self study:	90h	60.00%

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### Content

<p>1. Introduction to Science and Engineering of Materials</p>	<p>Learning time: 12h Theory classes: 2h Laboratory classes: 6h Self study : 4h</p>
<p>Description: 1.1 Science, Technology and Engineering of materials 1.2 Types of materials. Structural materials. Functional materials</p> <p>Related activities: Activity 1: Expositive class. Activity 2: Visit to laboratories. Activity 3: Bibliographical research Activity 16. Partial test Activity 17: Final test</p> <p>Specific objectives: Introduce to the student in the science and engineering of materials Understand the types of materials and their classification. Know the historical evolution of materials.</p>	
<p>2. Crystalline structure of materials</p>	<p>Learning time: 8h 50m Theory classes: 2h Guided activities: 0h 50m Self study : 6h</p>
<p>Description: 2.1 Crystalline structure. Crystallographic parameters and Bravais lattices 2.2 Main crystalline structures. Factor of packing. 2.3 Polymorphism and Allotropy. 2.4 Density: linear, planar and volumetric 2.5 X-ray diffraction: Bragg law 2.6 Crystal defects: punctual, linear or dislocations and superficial.</p> <p>Related activities: Activity 1: expositive class Activity 16. Partial test Activity 17: Final test</p> <p>Specific objectives: Know the concept of crystal Learn the crystallographic parameters Know the concept of density of a crystal.</p>	

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<h3>3. Diffusion</h3>	<p>Learning time: 6h 30m</p> <p>Practical classes: 2h Guided activities: 1h 30m Self study : 3h</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>5.1 Diffusion mechanisms.</li> <li>5.2 Fick's laws</li> <li>5.3 Diffusion and treatments of materials (applications)</li> </ul> <p>Related activities:</p> <ul style="list-style-type: none"> <li>Activity 1: expositive class</li> <li>Activity 13. Problems of diffusion. Applications of the Fick's laws to practical examples.</li> <li>Activity 16: Partial test</li> <li>Activity 17: Final test</li> </ul> <p>Specific objectives:</p> <ul style="list-style-type: none"> <li>Know the concept of diffusion.</li> <li>Analyze and understand the solution of the Fick's laws and its application to real cases.</li> </ul>	
<h3>4. Properties of materials</h3>	<p>Learning time: 47h 50m</p> <p>Theory classes: 3h Practical classes: 4h Laboratory classes: 14h Guided activities: 0h 50m Self study : 26h</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>4.1 Mechanical properties.</li> <li>4.2 Plastic deformation Mechanisms. Hardening mechanisms.</li> <li>4.3 Electrical, magnetic and thermal properties.</li> </ul> <p>Related activities:</p> <ul style="list-style-type: none"> <li>Activity 1. expositive class</li> <li>Activity 6. Problems related to the tensile test. Graphic stress-strain.</li> <li>Activity 7. Practice of laboratory: Tensile test</li> <li>Activity 8. Practice of laboratory: Hardness test (Brinell, Vickers, Rockwell) and micro-hardness test</li> <li>Activity 9. Practice of laboratory: Charpy impact test.</li> <li>Activity 10. Problems of electrical and magnetic properties</li> <li>Activity 11. Practice of laboratory: Measures of resistivity</li> <li>Activity 12. Practice of laboratory: Magnatest</li> <li>Activity 16. Partial test</li> <li>Activity 17: Final test</li> </ul> <p>Specific objectives:</p> <ul style="list-style-type: none"> <li>Know the main properties of materials: Mechanical, electrical, magnetic and thermal properties.</li> </ul>	

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<p>5. Equilibrium diagrams or phase diagrams</p>	<p>Learning time: 36h 30m</p> <p>Theory classes: 2h Practical classes: 6h Laboratory classes: 6h Guided activities: 0h 30m Self study : 22h</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>6.1 Solidification of a pure metal.</li> <li>6.2 Equilibrium diagrams.</li> <li>6.3 Invariant reactions.</li> <li>6.4 Types of diagrams and interpretation.</li> </ul> <p>Related activities:</p> <ul style="list-style-type: none"> <li>Activity 1: Expositive class</li> <li>Activity 14. Problems of equilibrium diagrams.</li> <li>Activity 15: Practice of laboratory: equilibrium diagrams (software)</li> <li>Activity 17: Final test</li> </ul> <p>Specific objectives:</p> <ul style="list-style-type: none"> <li>Know the process of solidification of a pure metal.</li> <li>Know what an equilibrium o phase diagram is.</li> <li>Know how to work with an equilibrium diagram and get information about the characteristics of a binary alloy.</li> </ul>	
<p>6. Heat treatments of metallic materials</p>	<p>Learning time: 10h 30m</p> <p>Theory classes: 2h Guided activities: 0h 30m Self study : 8h</p>
<p>Description:</p> <ul style="list-style-type: none"> <li>7.1 Types of heat treatments</li> <li>7.2 Heat treatments of quenching and tempering</li> <li>7.3 Heat treatments of solution and aging.</li> </ul> <p>Related activities:</p> <ul style="list-style-type: none"> <li>Activity 1: expositive class</li> <li>Activity 17: Final test</li> </ul> <p>Specific objectives:</p> <ul style="list-style-type: none"> <li>Know what a heat treatment is.</li> <li>Learn the effect of a heat treatment on the material properties.</li> </ul>	

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<p>7. Types of Materials</p>	<p>Learning time: 27h 50m</p> <p>Theory classes: 5h          Practical classes: 3h          Laboratory classes: 4h          Guided activities: 0h 50m          Self study : 15h</p>
<p>Description:</p> <p>3.1 Metallic materials: Metallic alloys; Main processes of conformation.          3.2 Ceramic materials: crystalline and non-crystalline (glasses) ceramics; Processes of conformation.          3.3 Polymeric materials: Types of polymers (thermoplastics, thermostables and elastomers).          3.4 Composites: General characteristics; Types of composites.</p> <p>Related activities:</p> <p>Activity 1: expositive class          Activity 5. Practice of laboratory: Metallography (preparation of metallographic samples and observation by optical microscopy).          Activity 17: Final test</p> <p>Specific objectives:</p> <p>Know the different types of materials          Learn the basic processes used for the conformation of materials</p>	

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### Planning of activities

<p><b>ACTIVITY 1: EXPOSITIVE CLASS</b></p>	<p>Hours: 56h Theory classes: 16h Self study: 36h Guided activities: 4h</p>
<p><b>Description:</b> Expositive class with some solved practical exercises by the professor.</p> <p><b>Support materials:</b> Provided material by the professor via Digital Campus, bibliography and specific software.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> The acquired knowledge would be evaluated in the first and the second exams (activities 16 and 17).</p> <p><b>Specific objectives:</b> Fundamental knowledge acquisition that it would be used in the other activities.</p>	
<p><b>ACTIVITY 2: VISIT TO THE LABORATORY</b></p>	<p>Hours: 2h Laboratory classes: 2h</p>
<p><b>Description:</b> The students will see the laboratories of the Department of Materials Science of the EPSEVG, both educational (L003, L004 i L007) and rsearch (VG5).</p> <p><b>Support materials:</b> Nothing</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> Questionnaire</p> <p><b>Specific objectives:</b> See the equipment used in the EPSEVG to the material characterization.</p>	
<p><b>ACTIVITY 3: PRACTICE OF LABORATORY: BIBLIOGRAPHICAL RESEARCH</b></p>	<p>Hours: 6h Laboratory classes: 4h Self study: 2h</p>
<p><b>Description:</b> The student will learn how looking for information related to the subject, both in the library of the EPSEVG or by Internet search in specialized journals, data bases, etc.</p> <p><b>Support materials:</b> Practice dossier (available in the digital campus), bibliography.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> When the student finishes the practice he/she will have to give the corresponding report. The evaluation of the task will contribute to a 20% of the final mark.</p> <p><b>Specific objectives:</b> Know where it is the recommended bibliography in the library of the EPSVG. Learn to look for information in bases of the UPC. Learn to look for information in data bases external to the UPC or in specialized journals.</p>	

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<b>ACTIVITY 5: PRACTICE OF LABORATORY: METALLOGRAPHY</b>	Hours: 7h Laboratory classes: 4h Self study: 3h
<p><b>Description:</b> The student will have to learn prepare a metallographic sample and use an optical microscope.</p> <p><b>Support materials:</b> Practice dossier (available in the digital campus), bibliography.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> When the student finishes the practice he/she will have to give the corresponding report. The evaluation of the task will contribute to a 20% of the final mark.</p> <p><b>Specific objectives:</b> Learn to prepare metallographic samples for its observation. Observation of the microstructure of different materials.</p>	
<b>ACTIVITY 6: PROBLEMS RELATED TO THE TENSILE TEST.</b>	Hours: 8h Practical classes: 2h Self study: 6h
<p><b>Description:</b> The student will have to solve the problems proposed by the professor.</p> <p><b>Support materials:</b> List of problems, bibliography and specific software.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> The students will have to present by oral or written form some of the resolute problems. The acquired knowledge would be evaluated in the first and second exams that among others evaluate this subject (Activities 16 and 17).</p> <p><b>Specific objectives:</b> Acquire ability in the use of stress <math>\sigma</math> strain graphics. Calculate the mechanical properties that are derived from a tensile test: maximum resistance, elastic limit, elastic module and elongation. Determine the coefficient of hardening of a metal from the data of a tensile test.</p>	
<b>ACTIVITAT 7: PRACTICE OF LABORATORY: TENSILE TEST</b>	Hours: 6h Laboratory classes: 4h Self study: 2h
<p><b>Description:</b> The student will perform a tensile test in two different materials: an aluminium alloy and steel.</p> <p><b>Support materials:</b> Practice dossier (available in the digital campus), bibliography, standards to carry out the test, specific software.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> When the student finishes the practice he/she will have to give the corresponding report. The evaluation of the task will contribute to a 20% of the final mark.</p>	

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### Specific objectives:

- Know the procedure of a tensile test machine
- Learn to determine the mechanical properties of a material from a real tensile test.
- Determine the coefficient of hardening of a metal from the real data of a tensile test.
- Interpret and analyze the results.
- Apply standards to carry out the test.

### ACTIVITY 8: PRACTICE OF LABORATORY: HARDNESS TEST (BRINELL, VICKERS, ROCKWELL) AND MICROHARDNESS

Hours: 6h  
Laboratory classes: 4h  
Self study: 2h

#### Description:

The student will perform a hardness test in different materials: an aluminum alloy, a copper alloy and steel.

#### Support materials:

Practice dossier (available in the digital campus), bibliography and standards to carry out the test.

#### Descriptions of the assignments due and their relation to the assessment:

When the student finishes the practice he/she will have to give the corresponding report. The evaluation of the task will contribute to a 20% of the final mark.

#### Specific objectives:

- Know the procedure of a hardness equipment
- Learn to determine the hardness of a material by means of the different types of hardness: Brinell, Vickers, Rockwell
- Learn to determine the micro-hardness of a material by means of a micro-hardness Vickers test.
- Interpret and analyze the results.
- Apply standards to carry out the test.

### ACTIVITY 9: PRACTICE OF LABORATORY: CHARPY IMPACT TEST.

Hours: 4h  
Laboratory classes: 2h  
Self study: 2h

#### Description:

The student will perform an impact test in steels with and without heat treatment (quenching and tempering).

#### Support materials:

Practice dossier (available in the digital campus), bibliography and standards to carry out the test.

#### Descriptions of the assignments due and their relation to the assessment:

When the student finishes the practice he/she will have to give the corresponding report. The evaluation of the task will contribute to a 20% of the final mark.

#### Specific objectives:

- Know the procedure of a Charpy pendulum
- Learn to determine the Resilience of a material.
- Learn the concepts of toughness and fragility
- Interpret and analyze the results.
- Apply standards to carry out the test.

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<b>ACTIVITY 10: PROBLEMS OF ELECTRICAL AND MAGNETIC PROPERTIES</b>	Hours: 4h Practical classes: 2h Self study: 2h
<p><b>Description:</b> The student will have to solve the problems proposed by the professor.</p> <p><b>Support materials:</b> List of problems, bibliography and specific software.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> The students will have to present by oral or written form some of the resolute problems. The acquired knowledge would be evaluated in the first and second exams that among others evaluate this subject (Activities 16 and 17).</p> <p><b>Specific objectives:</b>            Know the main concepts of electrical conductivity and magnetism.            Learn how determine the resistivity of materials and alloys.            Calculate the main magnetic variables (permeability, magnetization, etc.)</p>	
<b>ACTIVITY 11: PRACTICE OF LABORATORY: MEASURES OF RESISTIVITY</b>	Hours: 4h Laboratory classes: 2h Self study: 2h
<p><b>Description:</b> The student will determine the electrical resistivity of different steels and will evaluate the effect of the heat treatment in resistivity.</p> <p><b>Support materials:</b> Practice dossier (available in the digital campus) and bibliography.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> When the student finishes the practice he/she will have to give the corresponding report. The evaluation of the task will contribute to a 20% of the final mark.</p> <p><b>Specific objectives:</b>            Know the use of a voltmeter/ammeter.            Learn how to determine the electrical conductivity of a material            Interpret and analyze the results.</p>	
<b>ACTIVITY 13: PROBLEMS OF DIFFUSION. APPLICATIONS OF THE FICK'S LAWS TO PRACTICAL EXAMPLES.</b>	Hours: 3h Practical classes: 2h Self study: 1h
<p><b>Description:</b> The student will have to solve the problems proposed by the professor.</p> <p><b>Support materials:</b> List of problems, bibliography and specific software.</p>	

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Descriptions of the assignments due and their relation to the assessment:

The students will have to present by oral or written form some of the resolute problems. The acquired knowledge would be evaluated in the first and second exams that among others evaluate this subject (Activities 16 and 17).

Specific objectives:

Know the main diffusion concepts.

Determine the diffusivity and evaluate the temperature effect.

Analyze and understand the solution of the Fick's laws and its application to real situations.

### ACTIVITY 12: PRACTICE OF LABORATORY: MAGNATEST

Hours: 4h

Laboratory classes: 2h

Self study: 2h

Description:

The student will evaluate the microstructural differences between steel with different heat treatments from his different magnetic behavior.

Support materials:

Practice dossier (available in the digital campus) and bibliography.

Descriptions of the assignments due and their relation to the assessment:

When the student finishes the practice he/she will have to give the corresponding report. The evaluation of the task will contribute to a 20% of the final mark.

Specific objectives:

Know the use of the Magnatest equipment.

Evaluate the effect of the microstructure in the electrical and magnetic properties of a metallic material.

Know the applications of the equipment in the quality control of industrial processes.

Interpret and analyze the results.

### ACTIVITY 14: PROBLEMS OF EQUILIBRIUM DIAGRAMS.

Hours: 16h

Practical classes: 6h

Self study: 10h

Description:

The student will have to solve the problems proposed by the professor.

Support materials:

List of problems, bibliography and specific software.

Descriptions of the assignments due and their relation to the assessment:

The students will have to present by oral or written form some of the resolute problems. The acquired knowledge would be evaluated in the second exam that among others evaluate this subject (Activity 17).

Specific objectives:

Acquire ability in the use of binary equilibrium diagrams.

Calculate the chemical composition of phases (Rule of the horizontal)

Determine the proportion of phases (Rule of the Handle or the inverse segment)

Understand the invariant reactions.

Know the solidification process and cooling until room temperature of a metallic alloy and understand its microstructural evolution.

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<p><b>ACTIVITY 16: PARTIAL TEST</b></p>	<p>Hours: 2h 30m Theory classes: 1h 30m Guided activities: 1h</p>
<p><b>Description:</b> The student will have to do a written test on contents 1, 2, 3 and 4, in which he/she will have to solve some exercises and questions.</p> <p><b>Support materials:</b> Exam.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> Individual resolution of the proposed questions and exercises contributes to a 30% of the final mark.</p> <p><b>Specific objectives:</b> Consolidation of the knowledge acquired until the moment</p>	
<p><b>ACTIVITY 15: PRACTICE OF LABORATORY: EQUILIBRIUM DIAGRAMS.</b></p>	<p>Hours: 10h Laboratory classes: 6h Self study: 4h</p>
<p><b>Description:</b> The student will acquire the knowledge necessary to work and to obtain data of simple equilibrium diagrams.</p> <p><b>Support materials:</b> Practice dossier (available in the digital campus), bibliography and specific software.</p> <p><b>Descriptions of the assignments due and their relation to the assessment:</b> When the student finishes the practice he/she will have to give the corresponding report. The evaluation of the task will contribute to a 20% of the final mark.</p> <p><b>Specific objectives:</b> Acquire ability in the use of binary equilibrium diagrams. Calculate the chemical composition of phases (Rule of the horizontal) Determine the proportion of phases (Rule of the Handle or the inverse segment) Understand the invariant reactions. Know the solidification process and cooling until room temperature of a metallic alloy and understand its microstructural evolution.</p>	
<p><b>ACTIVITY 17: FINAL TEST</b></p>	<p>Hours: 2h 30m Theory classes: 1h 30m Guided activities: 1h</p>
<p><b>Description:</b> Written test in which the student will have to demonstrate the degree of acquisition of the knowledge acquired on the subjects explained during the course. In this test acquired knowledge about different subjects will be interrelated.</p> <p><b>Support materials:</b> Exam.</p>	

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Descriptions of the assignments due and their relation to the assessment:

Individual resolution of the proposed questions and exercises contributes to a 30% of the final mark.

Specific objectives:

Consolidation of the knowledge acquired during the course and their interrelation.

### ACTIVITY 4: SELECTION OF MATERIALS

Hours: 9h

Practical classes: 3h

Self study: 6h

Description:

The students will have to solve some questions proposed by the professor on selection of materials for an application.

Support materials:

Bibliography and specific software.

Descriptions of the assignments due and their relation to the assessment:

The students will have to present, by oral or written form, some of the resolute problems. The acquired knowledge would be evaluated in the second exam that among others evaluate this subject (Activity 17).

Specific objectives:

Acquire ability in the utilization of Ashby's diagrams.

Understand the relation between properties.

Know the criteria selection of a material based on the requirements of exploitation

### Qualification system

The evaluation of the course will become according to the following indicators:

T, Theory: F, Final Exam; PT1, average mid-term exam 1; PT2, mid-term exam 2

P, Solves exercises: Average of the different made exercises.

L, Practices of laboratory: Weighted average of the different programmed practices.

The grade of the course will be obtained applying the following criteria:

$$1. \text{ Final grade} = 0,7T (0,35\%PT1 + 0,35\%PT2) + 0,1P + 0,2L$$

$$2. \text{ Final grade} = 0,7 (\text{Final Exam}) + 0,1P + 0,2L$$

### Regulations for carrying out activities

All the planned activities in this subject have a part in which the students have to attend in person and another part in which the students have to do an independent learning. Before the classes of problems, the students will individually discuss individually or in small groups the proposed problems and will have to present their solution. The evaluation of this task will influence in the evaluation. For the practical exercises in the laboratory, the students have to previously know the fundamentals of each test and knowledge that results are expected for each test.

The conditions of accomplishment of the individual tests (Activities 16 and 17) would be with enough time.

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### Bibliography

#### Basic:

- Smith, William F. Fundamentos de la ciencia e ingeniería de materiales. 4a ed. México [etc.]: McGraw-Hill, 2006. ISBN 9701056388.
- Askeland, Donald R. Ciencia e ingeniería de los materiales. Madrid: International Thomson Editores, 2001. ISBN 8497320166.
- Shackelford, James F. Introducción a la ciencia de materiales para ingenieros. 7a ed. Madrid [etc.]: Pearson Educación, 2010. ISBN 9788483226599.
- Ashby, Michael F. Materiales para ingeniería, vol. 1, Introducción a las propiedades, las aplicaciones y el diseño. Barcelona [etc.]: Reverté, 2008. ISBN 9788429172553.
- Ashby, Michael F. Materiales para ingeniería, vol 2, Introducción a la microestructura, el procesamiento y el diseño. Barcelona: Reverté, 2008-2009. ISBN 9788429172560.
- Callister, William D. Ciencia e ingeniería de materiales. 2a ed. México, D.F: Reverté, 2016. ISBN 9788429172515.

#### Complementary:

- Ashby, Michael F. Engineering materials. 3rd ed. Oxford: Elsevier Butterworth-Heinemann, 2006-2010. ISBN 9780750663809 (V.1), 9780750663816 (V.2).
- Pero-Sanz Elorz, José Antonio. Ciencia e ingeniería de materiales : estructura, transformaciones, propiedades y selección. 5a ed. Madrid: Dossat 2000, 2006. ISBN 8496437442.