# Materials science and engineering

**Academic Year: ( 2023 / 2024 )** **Review date: 25/05/2023 17:03:35**

**Department assigned to the subject: Materials Science and Engineering and Chemical Engineering Department**

**Coordinating teacher: RABANAL JIMENEZ, MARIA EUGENIA**

**Type: Compulsory ECTS Credits : 6.0**

**Year : 2 Semester : 1**

**Branch of knowledge: Engineering and Architecture**

## REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Basic Chemistry

## LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CG1. Ability to solve problems with initiative, decision-making, creativity, critical reasoning and to communicate and transmit knowledge, skills and abilities in the field of Industrial Engineering.
CG9. Knowledge and ability to apply computational and experimental tools for the analysis and quantification of Industrial Engineering problems.
CG10. Ability to design and carry out experiments and to analyse and interpret the data obtained.
CG18. Knowledge of the fundamentals of materials science, technology and chemistry. Understanding the relationship between microstructure, synthesis/processing and properties of materials.
CG19. Knowledge and use of the principles of strength of materials.
RA1. Knowledge and understanding: Have basic knowledge and understanding of science, mathematics and engineering within the industrial field, as well as knowledge and understanding of Mechanics, Solid and Structural Mechanics, Thermal Engineering, Fluid Mechanics, Production Systems, Electronics and Automation, Industrial Organisation and Electrical Engineering.
RA2. Engineering Analysis: To be able to identify engineering problems within the industrial field, recognise specifications, establish different resolution methods and select the most appropriate one for their solution
RA4. Research and Innovation: To be able to use appropriate methods to carry out research and make innovative contributions in the field of Industrial Engineering.
RA5. Engineering Applications: To be able to apply their knowledge and understanding to solve problems and design devices or processes in the field of industrial engineering in accordance with criteria of cost, quality, safety, efficiency and respect for the environment.

## OBJECTIVES

In general, the student will develop general skills and will master the necessary knowledge to:
*.- Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, abilities and skills in the field of Industrial Engineering.
* .- Knowledge and ability to apply computational and experimental tools for the analysis and quantification of Industrial Engineering problems.
*.- Ability to design and carry out experiments and to analyze and interpret the data obtained.
* .- Knowledge of the fundamentals of science, technology and chemistry of materials. Understand the relationship between microstructure, synthesis or processing and the properties of materials.
* .- Knowledge and use of the principles of resistance of materials.
* .- Awareness of the multidisciplinary context of engineering

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## DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to Materials Science and Engineering
1.1. Materials Science and Engineering Framework. Concept
1.2. Types of Materials: Classification
1.3. Selection of materials
1.4. Relationship between structure, properties and processing
2. Bonding in solids
2.1. Types and nature of bonding in solids
2.2. Ionic bond
2.3. Covalent bond.
2.4. Metallic bond. Band theory and other theories
3. Crystalline structures
3.1. Energy and crystalline lattices
3.2. Description of the crystalline structure
3.3. Main metallic structures.
3.4. Interstitial and hole positions
3.5. Atomic positions, directions, and crystallographic planes
3.6. Comparison between FCC, HCP and BCC crystalline structures
3.7. Atomic density in crystals: linear, planar and volumetric
3.8. Packing factor: occupied volume/total volume
4. Defects in solids
4.1. Perfect and imperfect crystals: thermodynamic considerations.
4.2. Types of defects
4.3. Classification of defects: point, lineal, planar and surface.
4.4. Solid solutions in metals and ceramics.
5. Mass transport: diffusion.
5.1. Definition and mechanism of solid state diffusion.
5.2. Mechanism of solid state diffusion
5.3. Macroscopic laws governing diffusion.
5.4. Factors that influence the diffusion process
6. Phase equilibrium diagrams.
6.1. General concepts. Constituents, phases and components
6.2. Phase diagrams of one-component systems and Binary Systems
6.3. Ceramic phase diagrams
7. Charge Transport: Electrical Properties
7.1. Classification of materials based on their electrical properties.
7.2. Resistivity in Conductive Materials (metals)
7.3. Semiconductor materials.
7.4. Insulators and dielectric materials.
7.5. Application
8. Mechanical properties
8.1. Methods and Types of mechanical tests
Different mechanical test: Uniaxial tensile test: nominal stress and strain, Charpy method, flexion test,¿.
8.2. Hardening mechanisms
8.3. Hardness
9. Metallic Materials
9.1. Classification. Ferrous and non-ferrous alloys. General characteristics of:
9.2. Obtaining metallic materials: Solidification: Nucleation and Growth
9.3. 3.Forming by plastic deformation: Strain hardening
9.4. Steels: Transformations in equilibrium in the Fe-C system.
9.5. Steels: Transformations out of equilibrium in the Fe-C system.

10. Ceramic materials
10.1. General and particular properties and Classification.
10.2. Main ionic crystalline structures.
10.3. Structure of covalent ceramics.
10.4. Non-crystalline ceramic materials: glasses.
10.5. Fabrication and Processing of ceramic materials
11. Polymeric materials
11.1. Bond and general Characteristics
11.2. Reaction of synthesis: Polymerization
11.3. Thermal behaviour: thermal transitions: Tm and Tg
11.4. Classification of polymers: Thermoplastics, thermosets and elastomers
11.5. Mechanical behavior.
11.6. Processing of polymer materials
12. Composite materials.
12.1. Classification according to the type of reinforcement and matrix
12.2. Rule of mixtures
12.3. MC reinforced with particles (by dispersion and with particles)
12.4. Fiber-reinforced MC
12.5. Elastic properties (MC with polymeric matrix and continuous fibers)
12.6. Structural materials (laminates and sandwich structures)
12.7. Synthesis and Applications of MC
12.8. Processing of Composite Materials

## LEARNING ACTIVITIES AND METHODOLOGY

Masterly classes, classes to solve doubts in reduced groups, student presentations, individual tutorship and personal work of the student; oriented to acquire theoretical knowledge (3 ECTS credits).
Laboratory classes, classes for solving problems in reduced groups; individual tutorship and personal work of the student; oriented to acquire practical knowledge related to the subject program (3 ECTS credits).

The assistance to the laboratory sessions is MANDATORY. The entrance to the laboratory is enabled once the student has watched the general security video and the specific video for chemistry/materials lab and answered both tests correctly. THE STUDENT CAN NOT ENTER THE LABORATORY IF HE/SHE HAS NOT ANSWERED THE TESTS. THE NON-ASSISTANCE TO THE LABORATORY WITHOUT JUSTIFIED CAUSE IMPLIES SUSPENDING THE CONTINUOUS EVALUATION.

## ASSESSMENT SYSTEM

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|---|---|
| **% end-of-term-examination/test:** | 60 |
| **% of continuous assessment (assigments, laboratory, practicals…):** | 40 |

Continuous evaluation (40% of final weight) will have three parts: (I) MINIMUM of three exercises, during classes, with 10% weight (30% of final mark); (ii) laboratory practices, solving a questionnaire or test at the end, with a 10% weight.

Assessable activities could be carried out during the lectures in magistral classes, which could be taken into account for 0-10% of the continuous assessment.

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It is necessary to get at least a 4.0 on the final exam to pass the course. In addition, it will be impossible to pass the subject if in the final exams (ordinary and extraordinary exams) there are more than 1/3 of the questions with a zero in their grade.

## BASIC BIBLIOGRAPHY

- ASHBY MF, JONES DRH Materiales para Ingeniería 1. Introducción a las propiedades, las aplicaciones y el diseño¿, Reverté. 2008.

- ASKELAND DR. "Ciencia e Ingeniería de los Materiales",, International Thomson, 4ª Edición, Madrid, 2001.

- CALLISTER WD. "Ciencia e Ingeniería de los Materiales". Vol. I,, Ed Reverté, 3ª Edición, Barcelona, 1995.

- MANGONON PL. ¿Ciencia de Materiales. Selección y Diseño¿., Prentice Hall, 1ª Edición, Méjico, 2001.

- SHACKELFORD JF. "Introducción a la Ciencia de Materiales para ingenieros",, Prentice Hall, 4ª Edición, Madrid, 1998.

- SMITH WF.  "Fundamentos de la Ciencia e Ingeniería de Materiales",, McGraw-Hill, 3ª Edición, Madrid, 2003.

## ADDITIONAL BIBLIOGRAPHY

- ASHBY MF, JONES DRH Materiales para Ingeniería 1. Introducción a las propiedades, las aplicaciones y el diseño¿, Reverté, 2008

- J.M. Montes, F.G. Cuevas, J. Cintas Ciencia e Ingeniería de los Materiales, Paraninfo, 2014