



Universidad de Jaén
School of Engineering of Linares

Materials Science and Engineering

2023-2024

Grado en Ingeniería Química Industrial
Grado en Ingeniería Eléctrica
Doble grado en Ingeniería Eléctrica e Ingeniería Mecánica
Grado en Ingeniería Mecánica

CAREEA



Guías docentes UJA

Horarios de tutorías

Llamamientos PEVAU

Syllabus 2023-24 - 14712005 - Materials Science and Engineering (Ciencia e ingeniería de materiales)

Caption

- Level 1: Tutorial support sessions, materials and exams in this language
- Level 2: Tutorial support sessions, materials, exams and seminars in this language
- Level 3: Tutorial support sessions, materials, exams, seminars and regular lectures in this language

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DEGREE:	Grado en Ingeniería eléctrica (14712005)
FACULTY:	SCHOOL OF ENGINEERING OF LINARES
DEGREE:	Grado en Ingeniería química industrial (14412004)
FACULTY:	SCHOOL OF ENGINEERING OF LINARES
DEGREE:	Doble grado en Ingeniería eléctrica e Ingeniería mecánica (14812005)
FACULTY:	SCHOOL OF ENGINEERING OF LINARES
DEGREE:	Grado en Ingeniería mecánica (14612002)
FACULTY:	SCHOOL OF ENGINEERING OF LINARES
ACADEMIC YEAR:	2023-24
COURSE:	Materials Science and Engineering

SYLLABUS

1. COURSE BASIC INFORMATION

NAME: Materials Science and Engineering	ACADEMIC YEAR: 2023-24
CODE: 14712005 (*)	LEVEL: 2
LANGUAGE: English	SEMESTER: PC
ECTS CREDITS: 6.0	YEAR: 2

2. LECTURER BASIC INFORMATION

NAME: PÉREZ VILLAREJO, LUIS		
DEPARTMENT: U122 - INGENIERÍA QUIM., AMBIENTAL Y DE LOS MAT.		
FIELD OF STUDY: 065 - CIENCIA DE MATERIALES E INGENIERÍA METALÚRGICA		
OFFICE NO.: D - D-013	E-MAIL: lperezvi@ujaen.es	P: 953648633
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ORCID: https://orcid.org/0000-0002-6912-9844		
LANGUAGE: -	LEVEL: 2	

3. CONTENT DESCRIPTION

BLOCK 1. Crystalline systems.

UNIT 1. THE MATERIALS SCIENCE.

The choice of material. Materials Science: concept, relationship with the Engineering and Industry. Materials for Engineering: classification of materials based on atomic bonds. Structure and properties of materials. Selection of materials in engineering.

UNIT 2. CRYSTAL STRUCTURES. METALLIC CRYSTALS.

Matter states. Crystalline and amorphous substances. Space Network and Unit Cell. Crystal systems, Bravais lattices. Isomorphism, polymorphism and allotropy. Study of metal nets. Coordination number, atomic radius, atomic packing factor. Vacancies and self. Interstices. Interstitial sites. Impurities in solids. Dislocations-linear defects. Bulk or volume defects. Interstitial sites. Miller and Miller-Bravais indexes. Interplanar distance. Volume, linear and surface densities.

UNIT 3. CRYSTALLINE IMPERFECTIONS. Real solid. Influence of defects. Defects common in the crystal structure. Point defects: vacancies, interstitials, impurities, Frenkel and Schottky defects. Dislocations, Linear defects. Surface defects: crystal twinning, packing defects and grain boundaries.

BLOCK 2. Alloys.

UNIT 4. ALLOYS. Pure metals and alloys. Constitution alloys: components and constituents. Solid solutions and mechanical mixtures. Types of Solid Solutions. Hume-Rothery rules. Properties of solid

solutions. Solid solutions determinations. Intermediate stages: types and characteristics. Ordered Solid solutions: superlattices.

UNIT 5. HARDENING MECHANISMS AND RECRYSTALLIZATION PHENOMENA. Introduction. Hardening grain refinement. Alloying hardening. Precipitation hardening. Dispersion hardening. Temper hardening. Strain hardening. Creep. Variation of mechanical properties. Heating effects: recovery, recrystallization and grain growth. Recrystallization temperature.

BLOCK 3. Solidification and diffusion.

TOPIC 6. SOLIDIFICATION PROCESSES. Introduction. Solidification: homogeneous nucleation and heterogeneous nucleation. Determining the process variables: speed of nucleation and growth. Microstructure. Solidifying ingot: structures. Control of the structure: size, shape and orientation grain. Microstructural defects in solidification: segregations. macro-structural defects; blowholes, pores, cavities, cracks and splashes. Rapid solidification: metallic glasses.

UNIT 7. DIFFUSION. Introduction. Diffusion mechanisms. Volumetric diffusion: Fick laws. Factors affecting the diffusion. Other types of diffusion. Diffusion applications.

BLOCK 4. Phase diagrams.

UNIT 8. PHASE DIAGRAM. EQUILIBRIUM DIAGRAMS I. Materials system: components and phases. Equilibrium systems: balancing factors and degrees of freedom. Phase rule (Gibbs phase rule). Cooling curves. Two-component systems: experimental determination of diagrams. Distribution Mass: law of the lever. Interpretation rules.

UNIT 9. PHASE DIAGRAMS II. Types of binary diagrams. Total solid solubility diagrams. Total insolubility diagrams. Partial solubility diagrams: eutectic and peritectic reactions. Solid state changes: allotropy, order-disorder transformations, and peritectoid-eutectoid reactions. Diagrams complex: intermediate phases. Ternary diagrams. Non-equilibrium phase transformations.

BLOCK 5. Metals and thermal treatments.

UNIT 10. FERROUS ALLOYS: STEELS AND CAST IRONS. Introduction. Iron: states allotropic. The iron-cementite and iron-carbon diagrams. Classification of Fe-C alloys. Phases and constituents of equilibrium: definition of structures. Invariant transformations. Critical points. Irons: types and characteristics. Steels: classifications and mechanical properties. Steels alloyed: Influence of the alloying elements. Influence on the diagram Fe-Fe₃C. Alphas, gamma, and carbide formers elements. Effect on TTT curves. Steels Low and High alloy. Cast iron. Graphite forming elements and carbide formers. White and malleable cast iron. Spheroidal or ductile and gray castings. Mechanical properties of castings.

UNIT 11. ISOTHERMAL TRANSFORMATION DIAGRAM AUSTENITE. Introduction. Isothermal transformation of austenite. Pearlite and bainite. Martensitic transformation: properties. Relationship between cooling curves and I. T. diagrams Curves and transformation in continuous cooling.

UNIT 12. THERMAL TREATMENTS. Introduction. Classification and targets obtained with steel thermal treatments. Annealing. Normalizing heat treatment. Tempered steel. Factors affecting tempering. Rapid quench. Hardenability. Jominy test. Tempering. Tempering transformations. Tempering diagrams. Surface treatments; Thermal and thermochemical treatments.

UNIT 13. METALS AND ALLOYS NO TRACKS. Introduction. Unalloyed aluminum. Properties and applications. Aluminum alloys. Classification. Forge alloys: thermal treatments. Alloys for molding: Al-Si alloys modification. Properties and applications of aluminum alloys. Another light alloys. Unalloyed copper. Properties and applications. Copper alloys: brasses and bronzes. Applications and treatments.

BLOCK 6. Corrosion and control

UNIT 14. CORROSION AND PROTECTION. Introduction. Electrochemical fundamentals. Corrosion speed. Forms of corrosion. Corrosion protection. Coatings. Polymer degradation.

BLOCK 7. Polymer material

UNIT 15. STRUCTURE, BEHAVIOR AND PROCESSING OF POLYMERS. Introduction. Polymerization mechanisms. Polymer structure. General classification of polymers. Thermoplastics. Thermoset polymers. Elastomers. Mechanical behavior of polymers

Block 8. Ceramic materials. Ceramic processing and glasses

UNIT 16. CERAMIC AND GLASSES. Introduction. Structure of ceramic materials. Ionic crystals. Silicate structures. Properties of ceramic materials. Noncrystalline ceramic materials: glasses. Glass transition temperature. Ceramic and glass processing.

BLOCK 9. Composites

UNIT 17. COMPOSITES. MATRIX AND REINFORCEMENTS Introduction. Composite material concept. Matrix and reinforcement. Types of Matrices. Fiber reinforcement. Useful materials. Particle reinforcement. Considerations about matrices. Mechanical behavior. Applications.

BLOCK 10. Materials tests.

UNIT 18. STRESS TEST. (Laboratory) Mechanical behavior of materials: intrinsic and extrinsic conditions. Normal and shear stresses. Elastic behavior: module

of elasticity and yield strength. Plastic deformation: slipping and twinning. Schmid's law. Stress test. Definitions. Diagrams. Ductile and brittle fracture. Test run. Results.

UNIT 19. HARDNESS TESTS. (Laboratory) Hardness: types. Classification methods hardness measurement. Hardness tests by static indentation: Brinell, Vickers and Rockwell. Advantages and drawbacks. Other tests.

UNIT 20. IMPACT TESTS AND TECHNOLOGY. (Laboratory) Ductility, malleability, brittleness and tenacity. Ductile and brittle fracture. Influencing factors. Toughness tests. Types and dimensions of probes. Charpy test. Izod test. Bending test: fundamentals, bending diagram. Technology tests: folding, stamping, forging, cutting, punching.

UNIT 21. METALLOGRAPHIC TECHNIQUES. MACROSCOPY AND MICROSCOPY. (Laboratory) The Metallographic laboratory. Macroscopy: preparation and chemical attack. Macroscopic techniques. Microscopy: phases of sample preparation. Metallographic microscope. Observation of structural constituents. Grain size measurements.

UNIT 22. NON-DESTRUCTIVE TESTING. (Laboratory) Visual inspection. Radiographic inspection. Equipment and operating techniques. Protection and security measures. Ultrasonic inspection. Physical fundamentals. Nature and properties of the ultrasonic waves. Equipment and operating techniques. Magnetic methods. Physical fundamentals. Techniques and equipment. Crack surface detection. Penetrant liquids.

BLOCK 11. Basics of environmental technologies.

UNIT 23. ENVIRONMENTAL TECHNOLOGY. Materials and environmental. Environmental design factors. Urban and industrial waste. Recovery, reuse and recycling.

The contents connect with the Sustainable Development Goals (SDGs):

Goal 9: Industry, Innovation and Infrastructure.

Goal 11: Sustainable Cities and Communities

Goal 12: Responsible Consumption and Production

Goal 13: Climate Action

4. COURSE DESCRIPTION AND TEACHING METHODOLOGY

The lectures in large group will consist of lectures, theory and general examples, as well as introductory activities of the program content for the whole group in order to provide the student with a systematic overview of the different themes, highlighting the aspects more important of them, so that students clearly offered the possibility of motivation by experts in the field, through dialogue and exchange of ideas. Previous exposure of the objectives of each unit and its specific to the field of industrial engineering applications, provide a basis for focusing their interest and motivate learning. The subsequent development of each unit will be preceded by a general description of contents, illustrated through Microsoft Office PowerPoint presentations, of which students previously will have of in the ILIAS platform as well as the help of slate content that require it. On some issues, audiovisual sessions are used for a better understanding of the content. In these sessions the active participation of students will arise.

The practices academic sessions in the classroom are essential to strengthen and deepen the theoretical knowledge. They consist of the resolution of both Professor and student of problems concerning the topics covered in the lectures in large group. Besides discussions of those issues of greatest interest and relevance will be developed. On the other hand, experimental laboratory practices will be conducted in small groups (max. 20 students), which will be announced methodologies and relevant experimental techniques for the study of materials. Students will have a script beforehand with the documentation necessary for the implementation of practices. Practices consist of a brief theoretical explanation and then, explaining the operation of the instrument to be used. Later the student will to make this practice and preparing a report that will be evaluated.

Collective and individual tutoring: Where will be the supervision of targeted work, comments on individual jobs and clarification of doubts.

Several sessions will be held in the computer room in order to use the software CES EduPack for the use and selection of materials and fabrication processes.

To corroborate and / or supplement the results obtained in laboratory practices may be necessary to make analysis and / or testing in the Scientific and Technical Center of the University.

Students with special educational needs should contact the Student Attention Service (Servicio de Atención y Ayudas al Estudiante) in order to receive the appropriate academic support

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5. ASSESSMENT METHODOLOGY

Written exam on the dates officially listed in the student guide. This objective test will be to respond to short answers and/or test type in which the most important aspects of the subject are discussed, in addition to problem solving (CT2, CB2, CB3, CC3, CC10) questions (38; 39; 40; 41; 42; 43; 44).

To assess the laboratory practices, an practical exam will be made in which the student is facing the realization of one of the program's practices presented in the laboratory. (38; 39; 40) The reports about practices and proposed problems (; CT4;; CB4 CC3 CT2) will be assessed.

Delivery of proposed problems (CT2, CT4, CB2, CB3, CB4, CC3; CC10) (38; 39; 40; 41; 42; 43; 44).

Attendance and active participation in class (CB2, CB3, CB4, CC3, CC10).

In extraordinary call it will be guaranteed that the student can pass the subject, and if were necessary, obtain the highest grade, by performing an evaluation test.

In the case of changing to a multimodal scenario, the percentages will be identical to the face-to-face scenario. In this case, the exam will be online and there will be a built-in data protection clause. If the scenario were to move towards totally virtual teaching, both the evaluation and the weights would be the same as in the multimodal case.

6. BOOKLIST [\(Access the bibliography in the Library catalog\)](#)

MAIN BOOKLIST:

- Introducción a la ciencia e ingeniería de los materiales . Edition: Ed. en español, reimp. Author: Callister, William D. 1940-. Publisher: Reverté [\(Library\)](#)
- Materials science and engineering: an introduction . Edition: 10th. ed.. Author: Callister, William D.. Publisher: John Wiley [\(Library\)](#)
- Fundamentos de la ciencia e ingeniería de materiales . Edition: 5ª ed.. Author: Smith, William F.. Publisher: McGraw-Hill Education [\(Library\)](#)
- Introducción a la ciencia de materiales para ingenieros . Edition: 7ª ed.. Author: Shackelford, James F.. Publisher: Pearson Educación [\(Library\)](#)
- Ciencia e ingeniería de materiales . Edition: 6ª ed.. Author: Askeland, Donald R.. Publisher: CENGAGE Learning [\(Library\)](#)
- Problemas de ciencia de los materiales . Edition: -. Author: Varela Lafuente, Ángel.. Publisher: s.n.], [\(Library\)](#)
- Colección de problemas resueltos de ciencia de materiales aeroespaciales . Edition: -. Author: Pérez Soriano, Eva María.. Publisher: Editorial Universidad de Sevilla [\(Library\)](#)

ADDITIONAL BOOKLIST:

- Ciencia e ingeniería de materiales: estructura, transformaciones, propiedades y selección . Edition: 5ª ed. Author: Pero-Sanz Elorz, José Antonio 1934-2012.. Publisher: CIE Dossat 2000 [\(Library\)](#)
- Materiales compuestos . Edition: -. Author: Hull, Derek. Publisher: Reverté [\(Library\)](#)
- Metalurgia especial. Edition: -. Author: Herenguel, Jean. Publisher: Urmo [\(Library\)](#)
- Ciencia de los polímeros . Edition: -. Author: Billmeyer, Fred W.. Publisher: Reverté [\(Library\)](#)
- Materiales de ingeniería y sus aplicaciones . Edition: -. Author: Flinn, Richard A.. Publisher: McGraw-Hill Latinoamericana [\(Library\)](#)
- Tratamiento térmico de los aceros . Edition: 3ª ed. Author: Apraiz Barreiro, José.. Publisher: Escuela Téc. Superior de Ingenieros Industriales [\(Library\)](#)
- Fabricación de hierro, aceros y fundiciones . Edition: -. Author: Apraiz Barreiro, José.. Publisher: Urmo [\(Library\)](#)
- Aceros especiales y otras aleaciones. Edition: 5ª ed. Author: Apraiz Barreiro, José.. Publisher: Dossat [\(Library\)](#)
- Fractography: observing, measuring and interpreting fracture surface topography. Edition: -. Author: Hull, Derek. Publisher: Cambridge University Press [\(Library\)](#)
- Problemas de ciencia de los materiales . Edition: -. Author: Varela Lafuente, Ángel.. Publisher: s.n.], [\(Library\)](#)
- Introducción al conocimiento de los materiales y sus aplicaciones. Edition: -. Author: Barroso, Segundo.. Publisher: Universidad Nacional de Educación a Distancia [\(Library\)](#)
- Procesado y puesta en servicio de materiales. Edition: -. Author: Barroso, Segundo.. Publisher: UNED [\(Library\)](#)
- Ciencia de materiales: teoría, ensayos, tratamientos . Edition: [9ª ed.]. Author: Coca Rebollero, Pedro. Publisher: Pirámide [\(Library\)](#)
- Ciencia y tecnología de materiales: problemas y cuestiones. Edition: -. Author: Cembrero Cil, Jesús, coaut. Publisher: Pearson [\(Library\)](#)
- Corrosión y degradación de los materiales. Edition: -. Author: Otero Huerta, Enrique. Publisher: Sintesis [\(Library\)](#)
- Forensic engineering. Edition: 2nd ed.. Author: Carper, Kenneth L., ed. lit.. Publisher: Taylos & Francis [\(Library\)](#)
- Metal failures [electronic resource] : mechanisms, analysis, prevention . Edition: 2nd ed.. Author: McEvily, A. J.. Publisher: John Wiley & Sons, Inc. [\(Library\)](#)

- Colección de problemas resueltos de ciencia de materiales aeroespaciales . Edition: -. Author: Pérez Soriano, Eva María.. Publisher: Editorial Universidad de Sevilla ([Library](#))

7. VIRTUAL / CLASSROOM TEACHING SCENARIO

Multimodal or mixed scenario in which a mixed, hybrid or multimodal model that combines face-to-face and non-face-to-face teaching (asynchronous and synchronous) is contemplated.

The means and resources used in this scenario will be those provided by the University of Jaén, as well as other types of resources such as electronic bibliographic resources that do not require the physical presence in the library.

Depending on the number of students, it may occur that: a) There is a situation in which the number of students exceeds the capacity limited by the classroom. In this case, the promotional activities are planned as follows:

Formation activities	Format (classroom / online) *	Teaching methodology Description
14 practical sessions in specialized laboratories	In-person at 50%	Development of 14 practical sessions, lasting one hour each one, in laboratories applying rotation in small groups of 50%. Retransmission of practical classes to the rest of the group.
45 Theory sessions on the contents of the program	In-person at 50%	45 sessions of participatory master classes, lasting one hour each, held in the classroom and broadcast by videoconference to the rest of the group. Periodic rotation of students.
1 group tutoring session	In-person at 50%	1 hour-long group tutoring session, held in the classroom and broadcasting by videoconference to the rest of the group. Student rotation.
Tutoring	<i>On-site + Online</i>	Some tutoring sessions will be done in person and others online (synchronous and asynchronous)

- b) There is a situation in which the number of students is below the capacity limited by the classroom. In this case, the promotional activities are planned as follows:

Formation activities	Format (classroom / online) *	Teaching methodology Description
14 practical sessions in specialized laboratories	100% In-person	Development of 14 practical sessions, lasting one hour each one, in laboratories.
45 Theory sessions on the contents of the program	100% In-person	45 sessions of participatory master classes, lasting one hour each, held in the classroom.
1 group tutoring session	100% In-person	1 one-hour group tutoring sessions, held in the classroom and broadcasting by videoconference to the rest of the group. Student rotation.
Tutoring	<i>On-site + Online</i>	Some tutoring sessions will be done in person and others online (synchronous and asynchronous)

8. VIRTUAL TEACHING SCENARIO

Formation activities	Format (classroom / online)	Teaching methodology Description
14 practical sessions in specialized laboratories	No presential	Substitution of the 14 practical sessions for online training activities.

45 Theory sessions on the contents of the program	No presential	45 sessions of participatory master classes, lasting one hour each, conducted by videoconference.
1 group tutoring session	No presential	1 collective tutoring sessions, lasting one hour, by videoconference.
Tutoring	No presential	All tutoring sessions will be conducted online (synchronous and asynchronous)

DATA PROTECTION CLAUSE (on line exams)

Institution in charge of data processing: Universidad de Jaén, Campus Las Lagunillas, s/n, 23071 Jaén

Data Protection Delegate: dpo@ujaen.es

Purpose: In accordance with the Universities Law and other national and regional regulations in force, carrying out exams and assessment tests corresponding to the courses students are registered in. In order to avoid frauds while sitting the exam, the exam will be answered using a videoconference system, being able the academic staff of the University of Jaén to compare and contrast the image of the person who is answering the exam with the student's photographic files. Likewise, in order to provide the exam with evidential content for revisions or claims, in accordance with current regulation frameworks, the exam will be recorded and stored.

Legitimacy: compliance with legal obligations (Universities Law) and other national and regional regulations currently in force.

Addressees: service providers who are the owners of the platforms where the exams are carried out and with whom the University of Jaén has signed the corresponding data access contracts.

Storage periods: those established in current in force regulations. In the specific case of exam videoconference recordings, not before the examination records and transcripts are closed or the exam can still be reviewed or challenged.

Rights: you can exercise your right of access, amendment, cancellation, opposition, suppression, limitation and portability by sending a letter to the postal or electronic address indicated above. In the event that you consider that your rights have been violated, you may submit a complaint to the Andalusian Council for Transparency and Data Protection www.ctpdandalucia.es

CLASS RECORDING CLAUSE PERSONAL DATA PROTECTION

Person in charge: Universidad de Jaén, Paraje Las Lagunillas, s/n; Tel.953 212121; www.ujaen.es

Data protection delegate (DPO): TELEFÓNICA, S.A.U. ; Email: dpo@ujaen.es

Procedure aim: To manage proper recordings of teaching sessions with the aim of facilitating learning process under a multimodal and/or online teaching

Period for record storage: Images will be kept during legal term according to regulations in force

Legitimacy: Data will be managed according to legal regulations (Organic Law 6/2001, December 21, on Universities) and given consent provided by selecting corresponding box in legal admission documents

Data recipients (transfers or assignments): Any person allowed to get access to every teaching modality

Rights: You may exercise your rights of access, rectification, cancellation, portability, limitation of processing, deletion or, where appropriate, opposition. To exercise these rights, you must submit a written request to the Information, Registration and Electronic Administration Service of the University of Jaen at the address above, or by e-mail to the address above. You must specify which of these rights you are requesting to be satisfied and, at the same time, you must attach a photocopy of your ID card or equivalent identification document. In case you act through a representative, legal or voluntary, you must also provide a document that proves this representation and identification. Likewise, if you consider that your right to personal data protection has been violated, you may file a complaint with the Andalusian Data Protection and Transparency Council www.ctpdandalucia.es

