



## IDENTIFYING DATA

### Materials engineering

Subject	Materials engineering			
Code	V12G363V01502			
Study programme	Grado en Ingeniería en Tecnologías Industriales			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	3rd	1st
Teaching language	English			
Department				
Coordinator	Díaz Fernández, Belén			
Lecturers	Díaz Fernández, Belén			
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General description	This subject combines the scientific fundamentals that prove the relation structure-properties-performance with technological aspects such as the manufacturing processes and the service conditions.			

## Training and Learning Results

Code	
B3	CG3 Knowledge of basic and technological subjects that enable students to learn new methods and theories, and to adapt to new situations.
B4	CG4 Ability to solve problems through initiative, decision-making, creativity, critical reasoning, and to communicate and transmit knowledge, skills and abilities in the field of industrial engineering.
B5	CG5 Knowledge to carry out measurements, calculations, assessments, appraisals, surveys, studies, reports, work plans and other similar works.
B6	CG6 Capacity for handling specifications, regulations and mandatory standards.
B11	CG11 Knowledge, understanding and ability to apply the legislation relating to industrial installations.
C19	CE19 Knowledge and skills for engineering materials.
D1	CT1 Analysis and synthesis.
D5	CT5 Information Management.
D7	CT7 Ability to organize and plan.
D9	CT9 Application of knowledge.
D10	CT10 Self learning and work.
D15	CT15 Objectification, identification and organization.
D17	CT17 Working as a team.

## Expected results from this subject

Expected results from this subject	Training and Learning Results
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Knowledge of the main manufacturing and transformation processes used in the industry	B3	C19	D1
Probe the ability to select the most suitable forming process for each material	B4		D5
Knowledge of the joining processes used in the industry	B5		D7
Understand the complex relations between the properties of materials and the forming and joining processes in order to improve properties and to increase productivity	B6		D9
Knowledge of the characteristics of the materials used in engineering	B11		D10
Knowledge of the several types of materials and processes for their forming			D15
Knowledge of the criteria for the selection of the most suitable material for an specific application			D17
Propose operative solutions for the most common problems in the materials engineering field			
Analyse conclusions and results of tests and measurements			
Write with a suitable structure. Make a presentation with the available media			
Show the aptitude of communication and working in teams			
Identify the need of information and use the available media and services to design and perform a suitable search in the subject area			
Perform the assigned projects following the indications given by the lecturer			

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## Contents

### Topic

Unit I: In-service materials performance.	<p>Lesson 1. Fatigue Definition and importance. Fracture surface characteristics. S-N curve. Fatigue crack propagation and service life prediction. Cumulative fatigue damage: Palmgren-Miner's rule. Influence of the mean stress: Goodman and Gerber criteria. Factors that influence on fatigue.</p> <p>Lesson 2. Fracture mechanics. Griffith and Irwin theories. Linear elastic fracture mechanics. Stress distribution at the crack tip: plain stress and plain strain. Plain strain fracture toughness.</p> <p>Lesson 3. Creep. Influence of temperature on strength. The creep curve: creep rate, creep strain, temperature and stress. Creep tests for metals and plastics. Influence of stress and temperature. Prediction of long-time properties. Development of creep resistant alloys. Materials selection. Deformation mechanisms.</p> <p>Lesson 4. Fundamentals of corrosion. Economic and social importance. Electrochemical corrosion. Thermodynamic analysis. Electrode potential and Pourbaix diagrams. Kinetic analysis. Corrosion rate. Polarization phenomena. Passivation. Corrosion control strategies: design, change of material and/or exposure environment, protective layers, cathodic and anodic protection.</p>
Unit II: Metal-casting and forming processes, heat treatments and joining processes.	<p>Lesson 5: Fundamentals of metal casting: especial casting methods. Castability: fluidity, no cavities and resistance to hot cracking. Casting alloys. Directional solidification, casting for single-crystal components and metallic glasses. Squeeze casting. Semi-solid forming (rheocasting and thixocasting).</p> <p>Lesson 6: Plastic forming of metals: cold working and hot forming. Strain hardening. Characteristics of cold working. Annealing of a cold-worked piece. Hot forming: dynamic recovery and dynamic recrystallization. Characteristics of hot forming. Benefits of hot forming for cast structures.</p> <p>Lesson 7. Heat treatments and thermomechanical treatments. Quench and hardenability. Tempering. Martempering and austempering. Thermomechanical treatments: definition and types. Controlled rolling, ausforming, isoforming and marforming.</p> <p>Lesson 8. Welding metallurgy. Classification of welding processes according to AWS. Thermal cycle: influencing factors. Weld zone: epitaxial and competitive growth. Heat affected zone. Solid solution strengthened alloys. Work-hardened alloys. Precipitation hardened alloys. Transformation hardening alloys. Post-welding treatments.</p>

Unit III: Structural materials.

Lesson 9. Structural steels and stainless steels.  
Hot-rolled steels for general purposes. Microalloyed steels. Atmospheric corrosion resistant steels. Steels for quench and tempering. Low-temperature applications steels. Stainless steels. Passive layer characteristics. Classification.

Lesson 10. Aluminum alloys.  
Strengthening of aluminum alloys. Classification of the aluminum alloys. Cast and wrought aluminum alloys.

Lesson 11. Composite materials.  
Definition: advantages and drawbacks. Types of composite materials. Fiber-reinforced plastics: properties and fabrication. Laminated structures. Metallic and ceramic matrix composite materials.

Laboratory contents

Laboratory 1. Fractography and fatigue testing.  
Macroscopic and microscopic features of the fracture surfaces. Scanning Electron Microscope. Practical examples. Fatigue: general concepts. Fatigue testing: Wöhler curve. Factors that influence on fatigue. Examples.

Laboratory 2. Corrosion technology. Corrosion protection.  
Electrochemical techniques for the corrosion assessment. Metallographic analysis. Assessment of protective layers. Thickness and adherence. Assessment of failure mechanisms.

Laboratory 3. Metallography I: forming techniques.  
Cast structures: influence of cooling rate and alloying elements. Cold worked and hot formed structures.

Laboratory 4. Metallography II: heat-treated alloys.  
Steels and Al alloys.

Laboratory 5. Hardenability. Jominy test.  
Jominy curve. Objective and applications. Jominy test and results designation.

Laboratory 6. Liquid penetrating and magnetic particles testing.  
Definition, objectives and applications. Testing methodology and report.

Laboratory 7. Radiography and ultrasounds (I)  
Radiography: definitions, objectives and applications. Testing. Ultrasounds: through-transmission (transmitter-receiver) and pulse-echo modes. Ultrasonic inspection: calibration and thickness assessment.

Laboratory 8. Ultrasonic inspection (II)  
Inspections of metallic pieces with a contact transducer. In-situ assessment of concrete structures. Sclerometer test: surface hardening and strength relationship. Ultrasonic inspections with the direct transmission mode. Ultrasonic pulse velocity in concrete: indirect mode. Ultrasonic pulse velocity and strength relationship.

Laboratory 9. Exposition of projects. Each student will participate in the exposition of his/her group and will answer the questions posed either by the lecturer and/or by students from other groups.

<b>Planning</b>			
	Class hours	Hours outside the classroom	Total hours
Lecturing	33	56	89
Problem solving	4	8	12
Seminars	3	3	6
Laboratory practical	13	19	32
Mentored work	0	11	11

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

<b>Methodologies</b>	
	Description
Lecturing	Presentations given by the lecturer of the main contents of the subject

Problem solving	Proposal of a set of problems/exercises that students must resolve by themselves. Guidelines, required formulas and common routines will be given in the classroom. Some problem will be resolved at the classroom, by the lecturer or by a student.
Seminars	Additional explanations to solve the main difficulties about the subject contents
Laboratory practical	Activities for application of the theoretical knowledge to particular situations and for the acquisition of basic skills and procedures related to the subject. Students will use the laboratories with the suitable equipment and devices.
Mentored work	Students, individually or in group, elaborate a document or presentation about some important topic related to the subject. Student can be asked to prepare a seminar, a short research, a summary of a document or conference...

### Personalized assistance

#### Methodologies Description

Mentored work	Personalized attention, the lecturer will guide the preparation of the project. Any difficulty/doubt will be attended. This support can be provided either in person or electronically (email, videoconference, campus remoto ...) after being formally requested.
Seminars	Personalised attention, time devoted to help students with any difficulty or doubt. This support can be provided either in person or electronically (email, video-conference, campus remoto ...) after being formally requested.

### Assessment

	Description	Qualification	Training and Learning Results	
Lecturing	The assessment will be completed with two written exams of short questions, tests or exercises. The purpose is to assess the level of knowledge achieved along the course. One of the tests will be done during the learning period (30%) and the other in the date established by the administration (40%)	70	B3 B4 B5 B6 B11	D5 D7 D9 D10 D15
Laboratory practical	The laboratory activities will be assessed through the students attendance and participation, preparation of reports and a final test at the end of the learning period	20		D5 D9 D10 D15 D17
Mentored work	It will be assessed by the handed reports and/or the exposition in the classroom of the prepared project.	10	B3 B4 B11	D9 D10 D15

### Other comments on the Evaluation

#### FIRST ATTEMPT:

##### a) Option 1: continuous evaluation

The continuous assessment will be conducted during the learning process (teaching period of the subject) according to the criteria established in the previous section. The contribution of each item to the final score is as follows:

- 1) Laboratory work (20%). The contents worked in the laboratory will be assessed with an exam, that could be taken by the middle of December, in the week established by the administration for the continuous assessment tests. In addition, the attendance to the laboratory sessions as well as the preparation of reports will be considered.
- 2) Preparation and presentation of a project (10%).
- 3) Mid-term exam including some of the contents explained in the classroom (30%).
- 4) Final exam including the remaining contents (those not included in the mid-term exam, 40%). This exam will be taken in the data officially established by the administration.

A **minimum score, 40%**, is required in the two written exams (mid-term and final) to pass the subject under the continuous evaluation plan:

I. In case the minimum score was not achieved in the mid-term exam (1.2 out of 3), the student will be transferred to the comprehensive assessment methodology (option 2) after formally renouncing to the continuous evaluation option.

II. In case the **minimum score was not achieved in the final exam** (1.6 out of 4), the score achieved in items 1) and 2) will not be considered in the total grading.

**b) Option 2: comprehensive evaluation** Students have the right to renounce to the continuous assessment system. This option must be formally asked within the period established by the lecturer and informed at the beginning of the course. In this situation, a comprehensive final exam will be taken which includes the entirety of the contents of the subject (laboratory and theory), and its weight is 100%. The minimum score to pass it is 5 out of 10. The date of the exam will be fixed by the administration and can be checked at <http://eei.uvigo.es>.

**SECOND ATTEMPT (exam in July):**a) The score partially obtained from the continuous assessment option (items 1) and 2)) will be kept unless the student requests to be cancelled in due course (once cancelled student will be evaluated as described in b)). The exam will cover uniquely the contents explained in the classroom. The weight of this exam in the grading will be 70%, being a minimum of 40% (2.8 out of 7) required to pass. The final score will be the sum of the mark in this exam and the marks obtained in items 1) and 2). b) Under the comprehensive assessment system, the totality of the contents of the subject (those given in the classroom and in the laboratory) will be included in this final exam and the student could achieved 100% of the grading (the minimum mark to pass the exam will be 5 out of 10). The date of the exam will be fixed by the administration and can be checked at <http://eei.uvigo.es>.

**EXTRAORDINARY CALL:** the exam (questions, tests and/or exercises) will include the totality of the contents and the qualification will be 100%. **Ethical commitment:** student is expected to show an ethical behaviour. In the case a fraudulent behaviour is detected (copy, plagiarism, use of forbidden electronic devices, or others), the student will fail and its final score will be 0.

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#### Sources of information

##### Basic Bibliography

Kalpakjian, S. and Schmid, S. R., **Manufacturing Engineering and Technology**, Pearson/Prentice Hall,  
Mikell P. Groover, **Fundamentals of Modern Manufacturing: Materials, Processes, and Systems**, John Wiley & Sons,

Dieter, G. E., **MECHANICAL METALURGY**, McGraw-Hill Book Company,

##### Complementary Bibliography

Reina Gómez, M., **Soldadura de los aceros, aplicaciones.**, Gráficas Lormo,

Sindo Kou, **Welding Metallurgy**, John Wiley & Sons,

Krauss, G., **Steels: Heat Treatment and Processing Principles**, ASM International,

Brooks, CH., **Principles of the Surface Treatment of Steels.**, Inc. Lancaster,

Randall, M. G., **Sintering: Theory and Practice**, John Wiley & Sons,

Beeley, P., **Foundry Tecnology**, Butterworth-Heineman, Ltd.,

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#### Recommendations

##### Subjects that continue the syllabus

Fundamentals of manufacturing systems and technologies/V12G363V01402

Mechanics of materials/V12G363V01404

Manufacturing engineering/V12G363V01604

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##### Subjects that it is recommended to have taken before

Materials science and technology/V12G363V01301