

# Course guide

## 295710 - PME - Mechanical Properties of Materials

**Last modified:** 07/02/2022

**Unit in charge:** Barcelona East School of Engineering  
**Teaching unit:** 702 - CEM - Department of Materials Science and Engineering.

**Degree:** BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Compulsory subject).

**Academic year:** 2021    **ECTS Credits:** 6.0    **Languages:** Spanish

### LECTURER

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**Coordinating lecturer:** ORLANDO ONOFRE SANTANA PEREZ

**Others:** FERHUN CEM CANER BASKURT - Teoría  
LUIS MIGUEL LLANES PITARCH - Teoría  
ORLANDO ONOFRE SANTANA PEREZ - Teoría  
TOBIAS ABT - Sesiones de Prácticas  
LEANDRO MARTÍNEZ - Sesiones de prácticas  
MARC SERRA - Sesiones de prácticas

### PRIOR SKILLS

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### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

CE9. Knowledge of science, technology and materials' chemistry fundamentals. Understanding the relation between microstructure, synthesis or processing and materials' properties.

CEM1. Knowledge on several types of materials' structure, as well as analysis characterisation and techniques of materials.

CEMT-20. Knowledge of the mechanical, electronic, chemical and biological behaviour of materials, and the ability to apply it in designing, calculating and modelling aspects of elements, components and equipment.

**Transversal:**

04 COE N2. 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.

07 AAT N3. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.

### TEACHING METHODOLOGY

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Lectures on theoretical and problem-solving issues are given throughout the course. Evaluation is done on the basis of written exams and oral presentations of proposed activities.

### LEARNING OBJECTIVES OF THE SUBJECT

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The main objective of the course is that student understands the importance of structure - mechanical property correlation in the material selection process regarding structural applications, according to service conditions requirements. In doing so, basic concepts are given on mechanical response of materials, elastic deformation and plasticity, strengthening mechanisms, fracture, fatigue, and environmental effects. In all the cases special emphasis is done on critical design parameters and selection of specific materials for each service condition.



## STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	45,0	30.00
Hours small group	15,0	10.00

**Total learning time:** 150 h

## CONTENTS

### Topic 1. Configuration of the most used mechanical tests and parameters

#### Description:

- Evaluation of the subject and recommended bibliography.
- Definition of stress and unit deformation.
- Mechanical response of structural materials: basic concepts of elasticity and plasticity.
- Types of curves that relate sollicitation vs. mechanical response of the material: engineering, true and intrinsic. Characteristics that define them.
- Most used test configurations, mechanical parameters obtained and physical meaning, practical particularities of each configuration:
  - \* Traction
  - \* Flexion (at 3 and 4 points)
  - \* Uniaxial compression
  - \* Hardness (different configurations).
- Most used constitutive equations.

#### Related activities:

Laboratory sessions:  
Tensile tests on metals  
Flexural tests on polymers

**Full-or-part-time:** 32h 30m

Theory classes: 9h  
Practical classes: 4h  
Self study : 19h 30m

### Topic 2. Introduction to tensors

#### Description:

Definition and physical meaning.  
Components of a tensioner.  
Tension and strain tensor. Relationship between them. Definition of Poisson's ratio.  
Stress states: Plane stress vs. Plain strain. Triaxiality.  
Invariants of a tensor.  
Calculation with tensors.  
Invariants of a tensor. Calculus with tensors.

**Full-or-part-time:** 9h 45m

Theory classes: 2h 15m  
Guided activities: 0h 45m  
Self study : 6h 45m

### Topic 3. Elasticity of materials

**Description:**

Elasticity from the point of view of a tensor.

Generalized Hooke's Law. Elastic constants.

Isotropy Vs. Anisotropy.

Structural parameters of the material that govern this behavior. Effect of external factors: temperature.

**Full-or-part-time:** 18h 45m

Theory classes: 6h

Guided activities: 1h 30m

Self study : 11h 15m

### Topic 4. Plasticity of materials

**Description:**

Plasticity criteria: Tresca, Von Mises.

Effect of hydrostatic stress.

Construction Consider.

Constitutive equations and maximum load estimation: Ramberg-Osgood, Hollomon

**Full-or-part-time:** 18h 45m

Theory classes: 6h

Guided activities: 1h 30m

Self study : 11h 15m

### Topic 5. Viscoelasticity of materials

**Description:**

Introduction to linear viscoelasticity of materials.

Response in static solicitations: Creep tests, Stress ratio and Creep-recovery- Parameters that quantify it.

Boltzman superposition principle.

Time-temperature correspondence principle.

Micromechanical models: Maxwell, Kelvin-Voigt, Zener, 4 elements.

**Related activities:**

Laboratory sessions:

- Linear viscoelasticity range estimation in creep tests.

- Creep-recovery tests and adjustment to models.

**Full-or-part-time:** 30h 15m

Theory classes: 6h

Practical classes: 4h

Guided activities: 1h 30m

Self study : 18h 45m



## Tema 6. Elasticitat i Plasticitat en materials en polímers

### Description:

Types of engineering stress-strain curves in polymers and calculation of parameters in polymers.

Entropic elasticity.

Micromechanism of plastic deformation in polymers: Crazes and yielding by shear bands

### Related activities:

Laboratory sessions:

- Polymer tensile tests.

**Full-or-part-time:** 16h 15m

Theory classes: 4h 30m

Practical classes: 2h

Self study : 9h 45m

## Topic 7. Plastic deformation in metallic materials

### Description:

Theory of dislocations. Plastic deformation of single-crystals and poly-crystals. Mechanisms of deformation. Strengthening mechanisms: solid solution, aging, cold work, microstructural refinement, reinforcement through second phases (particles, fibers)

### Related activities:

Lab Sessions/Problems:

- Hardness tests on materials.
- Estimation of cold work in metals.

**Full-or-part-time:** 23h 45m

Theory classes: 6h

Practical classes: 2h

Guided activities: 1h 30m

Self study : 14h 15m

## GRADING SYSTEM

5 partial exams (ExPr1; ExPr2 ; ExPr3 ; ExPr4 and ExPr5 ) + Evaluation of group activities (NAg).

All evaluations will be on a scale of 10. IMPORTANT: ALL EVALUATION ITEMS ARE MANDATORY IN ORDER TO PASS THE SUBJECT. The course does not include a re-evaluation exam.

The definitive final grade (NF) will be calculated from the following expression(s) based on the student's performance and according to the following options:

Option 1: (If NTheory  $\geq$  5)

$$NF = 0.8 N_{\text{Theory}} + 0.2 N_{\text{AG}}$$

Note: in this case, the final exam is optional and must be communicated to the teacher. In case of taking the final exam, the final grade of the subject will be calculated according to the expression of Option 2).

NAG: average of the group activities that are proposed (practice reports, work, problems or deliverable reasoning questions).

$$N_{\text{theory}} = 0.2\text{ExP1} + 0.2\text{ExP2} + 0.2\text{ExP3} + 0.2\text{ExP4} + 0.2\text{ExP5}$$



## EXAMINATION RULES.

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The partial exams (ExPr) will be carried out within the timetable of the subject. No use of notes, unless indicated by the teacher. They will have a maximum duration of 75 min.

The laboratory reports will be presented in groups of a maximum of 3 students one week after the session. A template for the writing will be available.

## BIBLIOGRAPHY

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### Basic:

- Hosford, Williams. Mechanical behavior of materials. 1st. Cambridge: Cambridge University Press, 2005. ISBN 0521846706.
- Callister, William D.; Rethwisch, David G. Materials science and engineering : an introduction. 10th edition. Hoboken: John Wiley & Sons, 2020. ISBN 9781119453918.
- Askeland, Donald R.; Fulay, Pradeep P., Bhattacharya, D.K. Essentials of materials science and engineering. 2nd ed., SI. Stamford, CT: Cengage Learning, 2010. ISBN 9780495438502.
- Ward, IM ; Sweeney, J. Mechanical properties of solid polymers. 3d ed. Chichester: John Wiley & Sons, 2013. ISBN 978-1-4443-1950-7.

### Complementary:

- Meyers, M. A. ; Armstrong, R. W. Mechanics and materials: fundamentals and linkages. New York: John Wiley & Sons, 1999. ISBN 0471243175.
- McCrum, N.G. ; Buckley, C.P. ; Bucknall, C.B. Principles of polymer engineering. 2nd ed. Oxford, [etc.]: Oxford University Press, 1997. ISBN 0198565267.

## RESOURCES

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### Other resources:

Material docente disponible en ATENEA