Course guide
295710 - PME - Mechanical Propieties of Materials

Last modified: 14/06/2023

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: 2023 **ECTS Credits:** 6.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: ORLANDO ONOFRE SANTANA PEREZ

Others:

Primer quadrimestre:
TOBIAS MARTIN ABT - Grup: M11
FERHUN CEM CANER BASKURT - Grup: M11
LUIS MIGUEL LLANES PITARCH - Grup: M11
ORLANDO ONOFRE SANTANA PEREZ - Grup: M11
MARC SERRA FANALS - Grup: M11

Segon quadrimestre:
TOBIAS MARTIN ABT - Grup: M11, Grup: M12
NICOLAS CANDAU - Grup: M11, Grup: M12
FERHUN CEM CANER BASKURT - Grup: M11, Grup: M12
LUIS MIGUEL LLANES PITARCH - Grup: M11, Grup: M12
ORLANDO ONOFRE SANTANA PEREZ - Grup: M11, Grup: M12
MARC SERRA FANALS - Grup: M11, Grup: M12

PRIOR SKILLS

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE9. Knowledge of science, technology and materials' chemistry fundaments. 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

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

LEARNING OBJECTIVES OF THE SUBJECT

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 enviromental 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 solicitation 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: Ramber-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 ≥ 5)
NF = 0.8 NTheory + 0.2 NAG

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).
Ntheory = 0.2ExP1 + 0.2ExP2 + 0.2ExP3 + 0.2ExP3 +0.2ExP5

EXAMINATION RULES.

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

Basic:
- Callister, William D.; Rethwisch, David G. Materials science and engineering : an introduction. 10th edition. Hoboken: John Wiley & Sons, 2020. ISBN 9781119453918.
- Ward, IM ; Sweeney, J. Mechanical properties of solid polymers. 3d ed. Chichester: John Wiley & Sons, 2013. ISBN 978-1-4443-1950-7.
- Hosford, Williams. Mechanical behavior of materials. 1st. Cambridge: Cambridge University Press, 2005. ISBN 0521846706.
- 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.

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

Other resources:
Material docente disponible en ATENEA