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300215 - CTM - Materials Science and Technology

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering

Teaching unit: 748 - FIS - Department of Physics

Academic year: 2018

Degree: BACHELOR'S DEGREE IN AIR NAVIGATION ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AIRPORT ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERINGS/BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING - NETWORK ENGINEERING (AGRUPACIÓ DE SIMULTANEÏTAT) (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)

ECTS credits: 6 Teaching languages: Catalan, Spanish, English

Teaching staff

Coordinator: Definit a la infoweb de l'assignatura.

Others: Definit a la infoweb de l'assignatura.

Prior skills

The skills especially relevant to the CTM students are: the capacity of making mathematical operations to solve problems, the understanding of the general laws of thermodynamics and essential concepts of thermodynamics like the Gibbs free energy, activation energy and thermally-activated processes, processes controlled by kinetics, etc., and the understanding of the following concepts: the existing relationship between the electronic structure of the elements and their periodic properties; the main characteristics and physical and chemical properties of ceramics, metals, and polymers, based on their atomic structure and interatomic bonds; the amorphous and crystalline materials, monocrystals and polycrystals (concept of grain, grain boundary, etc.); crystalline structure of solid materials; crystallography (nomenclature of planes and directions, planar and linear density, etc.); imperfections of the crystalline structure (point, line -dislocations-, surface, and volumetric defects), how they work, and their relationship with plastic strain and irreversible processes; stress-strain fields associated to imperfections, especially dislocations and solute atoms, and mechanisms of interaction (attraction, repulsion) as a consequence of those fields; atomic diffusion in solid state (Fick ' s laws) and its temperature-dependence; possible industrial applications of diffusion; process of corrosion and substances and materials potentially corrosive, as a function of their chemical properties; and the impact of corrosion in the aeronautic sector.

Requirements

Prerequisites:
• having taken Ampliación de Matemáticas 2 (2A)
• having taken Termodinámica (2A)

Degree competences to which the subject contributes

Specific:

2. CE 11 AERO. Comprender las prestaciones tecnológicas, las técnicas de optimización de los materiales y la modificación de sus propiedades mediante tratamientos. (CIN/308/2009, BOE 18.2.2009)
4. CE 18 AERO. Conocimiento adecuado y aplicado a la Ingeniería de: Los fundamentos de la mecánica de fluidos; los

principios básicos del control y la automatización del vuelo; las principales características y propiedades físicas y mecánicas de los materiales. (CIN/308/2009, BOE 18.2.2009)
5. CE 19 AERO. Conocimiento aplicado de: la ciencia y tecnología de los materiales; mecánica y termodinámica; mecánica de fluidos; aerodinámica y mecánica del vuelo; sistemas de navegación y circulación aérea; tecnología aeroespacial; teoría de estructuras; transporte aéreo; economía y producción; proyectos; impacto ambiental. (CIN/308/2009, BOE 18.2.2009)
1. CE 7 AERO. Comprender el comportamiento de las estructuras ante las solicitaciones en condiciones de servicio y situaciones límite. (CIN/308/2009, BOE 18.2.2009)
3. CE 12 AERO. Comprender los procesos de fabricación. (CIN/308/2009, BOE 18.2.2009)

Generical:

10. EFFICIENT USE OF EQUIPMENT AND INSTRUMENTS - Level 2: Use the correct instruments, equipment and laboratory software for specific or specialized knowledge of their benefits. A critical analysis of the experiments and results. Correctly interpret manuals and catalogs. Working independently, individually or in groups, in the laboratory.
CG1. (ENG) CG1 - Capacidad para el diseño, desarrollo y gestión en el ámbito de la ingeniería aeronáutica que tengan por objeto, de
acuerdo con los conocimientos adquiridos, los vehículos aeroespaciales, los sistemas de propulsión aeroespacial, los materiales
aeroespaciales, las infraestructuras aeroportuarias, las infraestructuras de aeronavegación y cualquier sistema de gestión del espacio,
del trafico y del transporte aéreo.
CG2. (ENG) CG2 - Planificación, redacción, dirección y gestión de proyectos, cálculo y fabricación en el ámbito de la ingeniería aeronáutica que tengan por objeto, de acuerdo con los conocimientos adquiridos, los vehículos aeroespaciales, los sistemas de propulsión aeroespacial, los materiales aeroespaciales, las infraestructuras aeroportuarias, las infraestructuras de aeronavegación y cualquier sistema de gestión del espacio, del trafico y del transporte aéreo.
CG3. (ENG) CG3 - Instalación, explotación y mantenimiento en el ámbito de la ingeniería aeronáutica que tengan por objeto, de acuerdo con los conocimientos adquiridos, los vehículos aeroespaciales, los sistemas de propulsión aeroespacial, los materiales aeroespaciales, las infraestructuras aeroportuarias, las infraestructuras de aeronavegación y cualquier sistema de gestión del espacio, del trafico y del transporte aéreo.
CG4. (ENG) CG4 - Verificación y Certificación en el ámbito de la ingeniería aeronáutica que tengan por objeto, de acuerdo con los conocimientos adquiridos, los vehículos aeroespaciales, los sistemas de propulsión aeroespacial, los materiales aeroespaciales, las infraestructuras aeroportuarias, las infraestructuras de aeronavegación y cualquier sistema de gestión del espacio, del trafico y del transporte aéreo.

Transversal:

11. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.
12. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.
6. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 2. Applying sustainability criteria and professional codes of conduct in the design and assessment of technological solutions.
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
8. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
9. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.

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Teaching methodology

The educational methodologies to be used in the subject are:

• MD1 – Master class: Presentation of a logically structured topic with the purpose of facilitating information organized following adequate criteria with a given objective. This methodology focuses mainly on oral exposition, by the faculty, of contents on the issue under study.
• MD3 – Hands-on activity in the laboratory: Realization of hands-on activities for experimental formation of the students, which imply using experimental techniques, equipment and instrumentation in the laboratory for measurements customary of a field.
• MD4 – Problem/Project-based learning (PBL): Methodology in which the students work in teams to solve real problems, applying science and engineering knowledge, and experimenting to find solutions, in a multidisciplinary approach, such that, while they acquire and consolidate knowledge, other competences are developed like problem-solving or self-learning skills.
• MD5 – Autonomous work: Situations in which the student is asked to develop the adequate or correct solutions by means of exercising routines, the application of formulae or algorithms, the application of procedures of transformation of the available information and the interpretation of the results. This methodology assists all the other methodologies, i.e., the students are going to devote a large part of their time to personal work to strengthen and complete the information gathered in expositive and participative classes and to complete the problems, computations, reports, etc., that may result from their activity in the hands-on activities in the laboratory and the sessions for working on problems and projects with support of the faculty.
• MD6 – Cooperative work: Interactive approach of organization of the work in the classroom and out of it, where the students are responsible of their own learning and of the learning of their classmates in a situation of co-responsibility to meet their common objectives.
• MD7 – Tutorials: Monitoring of the student, with the purpose of facilitating the opening of a slot for communication, conversation and orientation, where the student has the possibility of reviewing and discussing, together with the tutor, topics of interest, anxiety, concern, as well as to improve the academic performance, to develop habitudes of studying, reflection and social coexistence.

Learning objectives of the subject

Upon finalization of the subject, the students should be capable of:

• Identifying and defining the mechanical properties of crystalline metallic materials.
• Identifying and defining the existing relationship between dislocations in crystalline materials and the phenomenon of plastic deformation.
• Identifying and defining the possible causes of failure and fracture the materials.
• Identifying and defining the phase transformations that can occur in a material.
• Identifying and defining the relationship between the microstructure and mechanical properties of materials, and understanding the impact of fabrication processes.
• Identifying and defining the applications of materials, and understanding the materials selection process according with their operative margins and the production processes.
• Identifying and defining the possible applications of composite materials used in the aerospace industry, and their production processes.
• Making simulations and advanced computations with mathematical models corresponding to the different physical phenomena studied.
• Using efficiently the equipment and instrumentation for measuring mechanical properties and for characterization of materials.

Similarly, other expected results of the learning process in CTM are:

• Understanding the structure and geometry of materials, as well as their physical, mechanical and technological

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properties, and their behavior under service conditions.
• Understanding the techniques for optimization of materials and for modification of their properties by means of treatments (heat treatments, etc.).

Study load

Total learning time: 150h	Hours large group:	23h	15.33%
	Hours medium group:	24h	16.00%
	Hours small group:	0h	0.00%
	Guided activities:	19h	12.67%
	Self study:	84h	56.00%

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Content

(ENG) - Mechanical properties of metallic materials

Learning time: 25h

Theory classes: 4h
Practical classes: 4h
Guided activities: 3h
Self study : 14h

Description:
- Introduction
- Concepts of stress, elongation and strain
- Concepts of tensile, flexural, compression, and shear loading
- Analysis of the elastic behavior of crystalline metallic materials under uniaxial loading:
  - Elastic properties of materials: stiffness, resilience, etc.
  - Anelasticity/viscoelasticity
- Analysis of the plastic behavior of the crystalline metallic materials under uniaxial loading:
  - Properties of the materials under uniaxial tensile loading: proportional limit and yield stress, tensile strength, fracture toughness, ductility, hardness, etc.
  - Real stress and strain vs. nominal stress and strain
  - Phenomena of elastic recovery and plastic deformation

Related activities:
- Related activities of guided learning:
  - Master classes in sessions of the Group of Theory (MD1)
  - Resolution of exercises and theoretical analyses in sessions of the Group of Problems, with discussion in the classroom about the appropriate methods of resolution (MD4, MD6)
  - Rated exercises done in class in small teams of students, in sessions of Guided Activities (MD4, MD6, MD7)
  - Realization of the hands-on activity in the laboratory with the universal testing machine, in session of the Group of Laboratory (MD3)
- Related activities based on autonomous work:
  - Studying the theoretical topics seen in class (MD5)
  - Solving of exercises (MD4, MD5, MD6)
  - Searches of information and diverse activities, as requested by the faculty (MD5)
  - Preparation of the rated exercises (MD4, MD5, MD6)
  - Realization of report on the hands-on activity with the universal testing machine (UTM) (MD4, MD5, MD6)
- Rated activities related with this topic:
  - EV1: Mid-term exam
  - EV2: Final exam
  - EV3: Rated exercises done in class in small teams of students
  - EV4: Report on the hands-on activity with the UTM
  - EV5: Report on the hands-on activity with the hardness tester

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(ENG) - Dislocations and strengthening mechanisms	Learning time: 25h Theory classes: 3h Practical classes: 4h Guided activities: 4h Self study : 14h

Description:
- Introduction
- Dislocations and plastic deformation:
  - o Basic concepts about dislocations and plastic deformation
  - o Types of dislocations and their characteristics
  - o Slip of dislocations: interaction between dislocations, slip systems, slip in mono-crystals, resolved shear stress, etc.
  - o Plastic deformation in polycrystalline metallic materials
- Strengthening mechanisms of crystalline metallic materials:
  - o Strengthening by grain size reduction
  - o Strengthening by solid solution
  - o Strengthening by application of plastic strain (cold work), and influence in the stress-strain diagram
- Heat treatments:
  - o Recovery
  - o Recrystallization
  - o Grain growth

Related activities:
- Related activities of guided learning:
  - o Master classes in sessions of the Group of Theory (MD1)
  - o Resolution of exercises and theoretical analyses in sessions of the Group of Problems, with discussion in the classroom about the appropriate methods of resolution (MD4, MD6)
  - o Rated exercises done in class in small teams of students, in sessions of Guided Activities (MD4, MD6, MD7)
- Related activities based on autonomous work:
  - o Studying the theoretical topics seen in class (MD5)
  - o Solving of exercises (MD4, MD5, MD6)
  - o Searches of information and diverse activities, as requested by the faculty (MD5)
  - o Preparation of the rated exercises (MD4, MD5, MD6)
  - o Realization of report on the hands-on activity with the universal testing machine (UTM) (MD4, MD5, MD6)
- Rated activities related with this topic:
  - o EV1: Mid-term exam
  - o EV2: Final exam
  - o EV3: Rated exercises done in class in small teams of students
  - o EV4: Report on the hands-on activity with the UTM
  - o EV5: Report on the hands-on activity with the hardness tester

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(ENG) - Failure and fracture of materials	Learning time: 25h Theory classes: 4h Practical classes: 4h Guided activities: 3h Self study : 14h

Description:
- Introduction
- Fracture:
  - o Fundamentals of fracture: ductile vs. fragile
  - o Fractography
  - o Theoretical materials vs. real materials
- Failure or fracture due to fatigue:
  - o Cyclic stresses: mean stress value, interval of stress, stress amplitude, and ratio of stresses
  - o Conventional fatigue tests
  - o S-N curve: fatigue life curve
  - o Process of fatigue fracture: nucleation and propagation of the fatigue crack, and crack growth rate
  - o Factors affecting fatigue and factors improving fatigue life
- Failure due to creep:
  - o Creep behavior: creep stages
  - o Mechanisms responsible for creep
  - o Design parameters for good creep behavior
  - o Influence of stress and temperature on the creep behavior
  - o Other factors that affect the creep behavior
  - o State of the art: ¿ Projection Concept or ¿ methodology
  - o Alloys for high temperature service conditions

Related activities:
- Related activities of guided learning:
  - o Master classes in sessions of the Group of Theory (MD1)
  - o Resolution of exercises and theoretical analyses in sessions of the Group of Problems, with discussion in the classroom about the appropriate methods of resolution (MD4, MD6)
  - o Rated exercises done in class in small teams of students, in sessions of Guided Activities (MD4, MD6, MD7)
- Related activities based on autonomous work:
  - o Studying the theoretical topics seen in class (MD5)
  - o Solving of exercises (MD4, MD5, MD6)
  - o Searches of information and diverse activities, as requested by the faculty (MD5)
  - o Preparation of the rated exercises (MD4, MD5, MD6)
  - o Realization of report on the hands-on activity with the universal testing machine (UTM) (MD4, MD5, MD6)
- Rated activities related with this topic:
  - o EV1: Mid-term exam
  - o EV2: Final exam
  - o EV3: Rated exercises done in class in small teams of students
  - o EV4: Report on the hands-on activity with the UTM

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(ENG) - Phase diagrams

Learning time: 19h

Theory classes: 4h
Practical classes: 2h
Guided activities: 2h
Self study : 11h

Description:

- Introduction
- Definitions and fundamental concepts about phase diagrams:
  - Solubility limit: solvus and liquidus
  - Concepts of component, phase, micro-constituent, monophasic system, mixture, etc.
  - Phase equilibrium: systems in equilibrium vs. systems out of the equilibrium (stable phases vs. metastable phases)
- Equilibrium phase diagrams:
  - Unitary systems
  - Binary isomorphic systems (rules of solubility): microstructure and properties in the different phase fields
  - Binary eutectic systems: microstructure and properties in the different phase fields; hypoeutectic vs. hypereutectic
  - Tie line and the leverage rule
  - Intermediate phases and intermetallic compounds
  - Eutectic, eutectoid, peritectic and peritectoid reactions
  - Phase transformations: congruent and incongruent
  - The rule of phases of Gibbs
- Steels: iron-carbon system (iron-cementite system):
  - Iron-carbon phase diagram
  - Eutectoid reaction (formation of pearlite)
  - Eutectoid steels, hipoeutectoid and hypereutectoid
  - Microstructure in iron-carbon alloys, and their properties

Related activities:

- Related activities of guided learning:
  - Master classes in sessions of the Group of Theory (MD1)
  - Resolution of exercises and theoretical analyses in sessions of the Group of Problems, with discussion in the classroom about the appropriate methods of resolution (MD4, MD6)
  - Rated exercises done in class in small teams of students, in sessions of Guided Activities (MD4, MD6, MD7)
- Related activities based on autonomous work:
  - Studying the theoretical topics seen in class (MD5)
  - Solving of exercises (MD4, MD5, MD6)
  - Searches of information and diverse activities, as requested by the faculty (MD5)
  - Preparation of the rated exercises (MD4, MD5, MD6)
  - Realization of report on the hands-on activity with the hardness tester (MD4, MD5, MD6)
- Rated activities related with this topic:
  - EV2: Final exam
  - EV3: Rated exercises done in class in small teams of students
  - EV5: Report on the hands-on activity with the hardness tester

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(ENG) - Phase transformations	Learning time: 25h Theory classes: 4h Practical classes: 4h Guided activities: 3h Self study : 14h

Description:
• Introduction
• Phase transformations:
o Fundamental concepts: types of transformations: simple diffusions, nucleation and growth transformations, and martensitic transformations
o Solid state reaction kinetics: JMAK (Avrami) model, reaction rate, Avrami index, and Arrhenius plot
o Multiphase transformations
• Relationship between applied heat treatments, evolution of the microstructure and mechanical properties, for aeronautic aluminum alloys:
o Precipitation sequences in aluminum alloys: Guinier-Preston zones, metastable phases and equilibrium phases
o Concept of coherent and incoherent precipitates
• Relationship between applied heat treatments, evolution of the microstructure and mechanical properties, for iron-carbon alloys (in particular, steels):
o Transformation-time-temperature (TTT) diagrams
o Transformations and microstructures out of the equilibrium (metastable): formation of coarse pearlite, thin pearlite, bainite, spheroidite, martensite and tempered martensite

Related activities:
• Related activities of guided learning:
o Master classes in sessions of the Group of Theory (MD1)
o Resolution of exercises and theoretical analyses in sessions of the Group of Problems, with discussion in the classroom about the appropriate methods of resolution (MD4, MD6)
o Rated exercises done in class in small teams of students, in sessions of Guided Activities (MD4, MD6, MD7)
• Related activities based on autonomous work:
o Studying the theoretical topics seen in class (MD5)
o Solving of exercises (MD4, MD5, MD6)
o Searches of information and diverse activities, as requested by the faculty (MD5)
o Preparation of the rated exercises (MD4, MD5, MD6)
o Realization of report on the hands-on activity with the hardness tester (MD4, MD5, MD6)
• Rated activities related with this topic:
o EV2: Final exam
o EV3: Rated exercises done in class in small teams of students
o EV5: Report on the hands-on activity with the hardness tester

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(ENG) - Metallic alloys	Learning time: 12h Theory classes: 2h Practical classes: 2h Guided activities: 2h Self study : 6h

Description:
- Introduction
- Techniques of fabrication of metallic components:
  - o Hechurado: forging, lamination, extrusion and trefilado
  - o Molding in sand, molding in cup and lost wax molding
  - o Other techniques: sintering and welding
- Ferrous alloys:
  - o Classification of iron alloys
  - o Properties of steels with low, medium and high carbon content
  - o Nomenclature of steels
  - o Iron-carbon casts: grey casts, ductile (spheroidal) casts, white casts and malleable casts
- Non-ferrous alloys:
  - o Aluminum alloys: nomenclature of aluminum alloys, families of alloys, treatments, Alclad, and structural applications in aerospace sector
  - o Titanium alloys
  - o Magnesium alloys
  - o Beryllium alloys
  - o Comparison of properties of light alloys en aeronautics
  - o Nickel and cobalt superalloys

Related activities:
- Related activities of guided learning:
  - o Master classes in sessions of the Group of Theory (MD1)
  - o Resolution of exercises and theoretical analyses in sessions of the Group of Problems, with discussion in the classroom about the appropriate methods of resolution (MD4, MD6)
  - o Rated exercises done in class in small teams of students, in sessions of Guided Activities (MD4, MD6)
  - o Realization of the hands-on activity in the laboratory with the hardness tester, in session of the Group of Laboratory (MD3)
- Related activities based on autonomous work:
  - o Studying the theoretical topics seen in class (MD5)
  - o Solving of exercises (MD4, MD5, MD6)
  - o Searches of information and diverse activities, as requested by the faculty (MD5)
  - o Preparation of the rated exercises (MD4, MD5, MD6)
  - o Realization of report on the hands-on activity with the hardness tester (MD4, MD5, MD6)
- Rated activities related with this topic:
  - o EV2: Final exam
  - o EV3: Rated exercises done in class in small teams of students
  - o EV5: Report on the hands-on activity with the hardness tester

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(ENG) - Composite materials (composites)

Learning time: 19h

Theory classes: 2h
Practical classes: 4h
Guided activities: 2h
Self study : 11h

Description:

- Introduction
- Fundamental concepts of composite materials:
  - Definition of composite materials
  - Substantial and structural action
  - Concept of matrix and reinforcement, and usual materials
  - Factors that affect the mechanical properties
- Methods of fabrication of composite materials:
  - Selection of the most appropriate fabrication method
  - Classification of the fabrication methods
  - Description and characteristics of each method
- Classification of composite materials:
  - Classification according to the matrix material
  - Classification according to reinforcement shape or material
- Composite materials reinforced with fibers:
  - Purpose of the matrix and purpose of the reinforcement
  - Mechanical properties: influence of the type of fiber and the length and orientation of the fibers
  - Laminate composite materials: concept of stacking sequence, golden rules and their impact on the properties
  - Mechanical properties of laminates: Rule of mixtures
- Composite materials reinforced with particles
- Structural composite materials:
  - Traditional solutions for stiffening of thin structures
  - Sandwich panels
  - Sandwich panels with honeycomb core

Related activities:

- Related activities of guided learning:
  - Master classes in sessions of the Group of Theory (MD1)
  - Resolution of exercises and theoretical analyses in sessions of the Group of Problems, with discussion in the classroom about the appropriate methods of resolution (MD4, MD6)
  - Rated exercises done in class in small teams of students, in sessions of Guided Activities (MD4, MD6, MD7)
- Related activities based on autonomous work:
  - Studying the theoretical topics seen in class (MD5)
  - Solving of exercises (MD4, MD5, MD6)
  - Searches of information and diverse activities, as requested by the faculty (MD5)
  - Preparation of the rated exercises (MD4, MD5, MD6)
- Rated activities related with this topic:
  - EV2: Final exam
  - EV3: Rated exercises done in class in small teams of students

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Planning of activities

(ENG) EV1 - MID-TERM EXAM	Hours: 2h Theory classes: 2h

Description:
- Among the different rated activities that the students must do individually, there is the mid-term exam of 2h in duration in the middle of the semester
- By means of this exam, the faculty will be able to evaluate to which level the students have learned the contents of the subject corresponding to the first half of the semester: topics #1, #2 and #3, as shown in Section 2.2.6
- The exam consists of a first part with around 20 test questions and another part with around 2 to 4 exercises about the theoretical and practical contents developed in class and in the laboratory
- Each part of the exam (test questions, on one side, and exercises, on the other) accounts for approx. 50% of the total mark of the exam

Support materials:
- Calculator, ruler, pen, pencil, eraser, and triangle
- Documentation provided by the faculty at the beginning of the activity or during the activity

Descriptions of the assignments due and their relation to the assessment:
- The students must solve, in the classroom and individually, the test questions and exercises in the statement of the exam
- When the time allocated for the realization of the exam (2h) is over, the students must hand in their answers to the test questions and their resolutions of the exercises
- Around 50% of the final mark of the mid-term exam (EV1) comes from the mark of the test questions (questions incorrectly answered subtract 1/(N-1) points, being N the number of possible options in the test), and the remaining 50% comes from the mark of the exercises
- EV1 corresponds to 32.5% of the global mark of the subject

Specific objectives:
- Assessment by the faculty of the level of guided and autonomous learning achieved by the students during the first half of the semester
- The goal is also to assess the level with which the students have acquired the following competences of the degree to which the subject is contributing:
  - Basic: CB1 and CB5
  - Generic: CG1, CG2, CG3 and CG4
  - Transversal: CT5 and CT6
  - Specific: CE11, CE18 and CE19

(ENG) EV4 - HANDS-ON ACTIVITY WITH UNIVERSAL TESTING MACHINE (UTM)	Hours: 1h Laboratory classes: 1h

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Description:
• Among the different rated activities based on teamwork or cooperative learning, the students must do a report about the hands-on activity in the laboratory with the universal testing machine
• In this activity, the students, in teams of 3, will solve exercises and questions about the experiments done in the laboratory, as requested in the statement of work of the hands-on activity
• To make the most of this hands-on activity, it will be scheduled preferably in a session in the 4th or 5th school week, after having completed at least topic #1, and, if possible, also topic #2
• Attendance to the hands-on activity in the laboratory is mandatory. Only properly justified absences due to major causes will be admitted

Support materials:
• Calculator, ruler, pen, pencil, eraser, and triangle
• Computer with internet and/or adequate software
• Statement of work of the hands-on activity, with exercises and questions about the experiments
• Metallic samples and universal testing machine in the aerospace laboratory or materials laboratory

Descriptions of the assignments due and their relation to the assessment:
• The students must solve, out of school time and in teams of 3, the exercises and questions of the statement of work
• Before the deadline, around 1 or 2 weeks after the session in the laboratory, the teams must deliver to the faculty a report with the resolutions of the exercises and questions in the statement of work
• The mark of the report on the hands-on activity with the universal testing machine (EV4) corresponds to 10% of the global mark of the subject

Specific objectives:
• Assessment by the faculty of the level of guided and autonomous learning achieved by the students, about the different theoretical and practical contents seen in the subject, and their teamwork and cooperative work skills
• The goal is also to assess the level with which the students have acquired the following competences of the degree to which the subject is contributing:
  o Basic: CB1, CB2 and CB5
  o Generic: CG9
  o Transversal: CT4, CT5, CT6, CT7 and CT8
  o Specific: CE11, CE18 and CE19

(ENG) EV3 - RATED PROBLEMS REALIZED IN CLASS-TIME	Hours: 10h Laboratory classes: 10h

Description:
• Among the different rated activities based on teamwork or cooperative learning of the students, there is the realization of rated exercises in class
• In this activity, the students, in teams of 2, will solve exercises about the contents of the subject, during the weekly session of Guided Activities, except the 2 weeks scheduled for laboratory sessions
• The activity may consist in, e.g., solving exercises about mechanical properties of materials, dislocations and strengthening mechanisms, failure and fracture of materials, phase diagrams and transformations, composite materials, etc.
• The students may be helped by the faculty before and during the resolution of the exercises in the classroom

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Support materials:
- Ruler, pen, pencil, eraser, and triangle
- Calculator or computer with internet and/or adequate software
- Documentation provided by the faculty before the activity, at the beginning of the activity or during the activity, and/or documentation obtained by the students (e.g., lecture notes, presentations from the class, books and other references, except the solutions of the exercises that students may have prepared previously)

Descriptions of the assignments due and their relation to the assessment:
- The students must solve, in the classroom in teams of 2, the questions and exercises of the statement of work
- When the time allocated for the realization of the exercises (1h) is over, the teams of students must hand in their resolutions of the exercises
- The average mark of the rated exercises (EV3) corrected by the faculty corresponds to 15% of the global mark of the subject

Specific objectives:
- Assessment by the faculty of the level of guided and autonomous learning achieved by the students, about the different theoretical and practical contents seen in the subject, and their teamwork and cooperative work skills
- The goal is also to assess the level with which the students have acquired the following competences of the degree to which the subject is contributing:
  - Basic: CB1, CB2 and CB5
  - Generic: CG1, CG2, CG3 and CG4
  - Transversal: CT4, CT5 and CT6
  - Specific: CE11, CE18 and CE19

(ENG) EV5 - HANDS-ON ACTIVITY WITH HARDNESS TESTER

Hours: 1h
Laboratory classes: 1h

Description:
- Among the different rated activities based on teamwork or cooperative learning, the students must do a report about the hands-on activity in the laboratory with the hardness tester
- In this activity, the students, in teams of 3, will solve exercises and questions about the experiments done in the laboratory, as requested in the statement of work of the hands-on activity
- To make the most of this hands-on activity, it will be scheduled preferably in a session in the 9th or 10th school week, after having completed at least topic #4, and, if possible, also topic #5
- Attendance to the hands-on activity in the laboratory is mandatory. Only properly justified absences due to major causes will be admitted

Support materials:
- Calculator, ruler, pen, pencil, eraser, and triangle
- Computer with internet and/or adequate software
- Statement of work of the hands-on activity, with exercises and questions about the experiments
- Metallic samples and universal testing machine in the aerospace laboratory or materials laboratory

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Descriptions of the assignments due and their relation to the assessment:
- The students must solve, out of school time and in teams of 3, the exercises and questions of the statement of work
- Before the deadline, around 1 or 2 weeks after the session in the laboratory, the teams must deliver to the faculty a report with the resolutions of the exercises and questions in the statement of work
- The mark of the report on the hands-on activity with the hardness tester (EV5) corresponds to 10% of the global mark of the subject

Specific objectives:
- Assessment by the faculty of the level of guided and autonomous learning achieved by the students, about the different theoretical and practical contents seen in the subject, and their teamwork and cooperative work skills
- The goal is also to assess the level with which the students have acquired the following competences of the degree to which the subject is contributing:
  - o Basic: CB1, CB2 and CB5
  - o Generic: CG9
  - o Transversal: CT4, CT5, CT6, CT7 and CT8
  - o Specific: CE11, CE18 and CE19

(ENG) EV2 - END-OF-TERM EXAM	Hours: 2h Theory classes: 2h

Description:
- Among the different rated activities that the students must do individually, there is the final exam of 2h in duration at the end of the semester
- By means of this exam, the faculty will be able to evaluate to which level the students have learned all the contents of the subject, but especially those corresponding to the second half of the semester: topics #4, #5, #6 and #7, as shown in Section 2.2.6
- The exam consists of a first part with around 20 test questions and another part with around 2 to 4 exercises about the theoretical and practical contents developed in class and in the laboratory
- Each part of the exam (test questions, on one side, and exercises, on the other) accounts for approx. 50% of the total mark of the exam

Support materials:
- Calculator, ruler, pen, pencil, eraser, and triangle
- Documentation provided by the faculty at the beginning of the activity or during the activity

Descriptions of the assignments due and their relation to the assessment:
- The students must solve, in the classroom and individually, the questions and exercises in the statement of the exam
- When the time allocated for the realization of the exam (2h) is over, the students must hand in their answers to the test questions and their resolutions of the exercises
- Around 50% of the final mark of the mid-term exam (EV2) comes from the mark of the test questions (questions incorrectly answered subtract 1/(N-1) points, being N the number of possible options in the test), and the remaining 50% comes from the mark of the exercises
- EV2 corresponds to 32.5% of the global mark of the subject

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Specific objectives:
- Assessment by the faculty of the level of guided and autonomous learning achieved by the students during all the semester, but with special attention to the second half of the semester
- The goal is also to assess the level with which the students have acquired the following competences of the degree to which the subject is contributing:
  - o Basic: CB1 and CB5
  - o Generic: CG1, CG2, CG3 and CG4
  - o Transversal: CT5 and CT6
  - o Specific: CE11, CE18 and CE19

Qualification system

Defined in the course webpage at the EETAC website.

Regulations for carrying out activities

The rules of realization of the rated activities of the subject are:

• The faculty will strive to publish, at the beginning of the academic course, the dates of the different rated activities and the deadlines for delivery of the corresponding reports, works, rated exercises, etc. If this is not possible, these dates will be notified to the students as soon as possible, as well as any modification in the dates, such that the students can prepare adequately for these rated activities well in advance.
• For the realization of the activities explained in the previous section, it is necessary to bring the appropriate support material as indicated by the faculty well in advance.
• The delays in the delivery of reports, works, rated exercises, etc., will result in a corresponding penalization on the mark of the activity delivered with delay.
• Plagiarism in rated activities, if these account for a significant percentage of the global mark of CTM, will result in both the mark of the activity and the global mark being rated with zero.
• Attendance to specific sessions (particularly, the two hands-on activities in the laboratory) is mandatory. Only properly justified absences due to major causes will be admitted.
• In the hands-on activities in the laboratory, students must follow the basic rules of safety and hygiene.

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Others resources:

List of other resources that may be used in the subject:

- Presentations of the master classes in pdf or power point format
- Software and support material in printed or digital format
- Statements of work of different activities, like problems to be done in class or hands-on activities in the aerospace laboratory
- Multimedia material, like photos or videos, created ad hoc or obtained from the internet

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