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 ENGINEERING/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: JOSE IGNACIO ROJAS GREGORIO

Others: Primer quadrimestre:
- SANTIAGO ARIAS CALDERON - 4GM51, 4GT41, 4GT42
- JOSE IGNACIO ROJAS GREGORIO - 4GM51, 4GT41, 4GT42

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

Prerequisite:
- Have completed knowledge in Physics fundamentals.
- Have completed knowledge in Calculus.
- Have completed knowledge in Chemistry.
- Have completed knowledge in Thermodynamics.
Degree competences to which the subject contributes

Specific:
1. 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)
2. 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)
3. 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)

Generical:
9. 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.

Transversal:
4. 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.
5. 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.
10. EFFECTIVE USE OF INFORMATION 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.

Teaching methodology
- Guided learning/activities rely on lectures by the teacher in which the several topics of the subject are presented. These theoretical explanations are combined with exercises and case studies presented to the students. The goal of the latter is increase their motivation and complement, in a more practical sense, the theoretical explanations.
- Generally, after each session, several tasks are proposed as homework, such as guided readings and resolution of questions and problems individually or in groups. These activities will be the basis of guided learning and self-learning.
- Similarly, throughout the course, each student should work in a group to elaborate a report of the hands-on activity with the UTM and another report of the hands-on activity with the hardness tester.

Learning objectives of the subject
At the end of the subject of Materials Science and Technology the student should be able to:
- Identify and define the mechanical properties of metallic materials.
- Identify and define the relationship between dislocations' behaviour and the phenomenon of plastic deformation in crystalline materials.
- Identify and define the possible causes of failure and fracture of materials.
- Identify and define the phase changes that can occur in a material.
· Identify and define the relationship between a material microstructure and its mechanical properties.
· Identify and define the applications of alloys and its production processes.
· Identify and define the possible applications of composite materials used in the aerospace industry and its production processes.

## Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group: 26h 17.33%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 26h 17.33%</td>
</tr>
<tr>
<td></td>
<td>Hours small group: 0h 0.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 14h 9.33%</td>
</tr>
<tr>
<td></td>
<td>Self study: 84h 56.00%</td>
</tr>
</tbody>
</table>
300215 - CTM - Materials Science and Technology

## Content

<table>
<thead>
<tr>
<th>(ENG) - Propiedades mecánicas de los materiales metálicos</th>
<th>Learning time: 25h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 15h</td>
</tr>
</tbody>
</table>

### Description:

- Introduction
- Concepts of stress and strain
- Analysis of the elastic deformation
  - Stress-strain behaviour under tensile stress
  - Anelasticity
  - Elastic properties of materials
- Analysis of the plastic deformation
  - Tensile properties
  - True stress and strain
  - Elastic recovery after plastic deformation
  - Hardness

### Related activities:

- Guided activities:
  - AD1: Resolution of exercises and problems by the students as homework.
  - AD2: Discussion of exercises, problems and theoretical analyses in the classroom. Collective discussion of proper resolution methods.
  - AD3: Realization of a paper involving research and processing of information relating to Materials Science and Technology.

- Rated activities (AE):
  - AE1: Mid-term exam about theoretical concepts.
  - AE2: 1st control about theoretical concepts.
  - AE3: Rated exercises made in the classroom.
### (ENG) - Dislocaciones y mecanismos de endurecimiento

#### Learning time: 25h
- Theory classes: 2h
- Laboratory classes: 4h
- Guided activities: 4h
- Self study: 15h

#### Description:
- **Introduction**
- **Dislocations and plastic deformation**
  - Basic concepts
  - Characteristics of dislocations
  - Slip systems
  - Slip in single crystal
  - Plastic deformation of polycrystalline materials
- **Mechanisms of strengthening in materials**
  - Strengthening by grain size
  - Solid-solution strengthening
  - Strain hardening
- **Thermal treatment**
  - Recovery
  - Recrystallization
  - Grain growth

#### Related activities:
- **Guided activities:**
  - AD1: Resolution of exercises and problems by the students as homework.
  - AD2: Discussion of exercises, problems and theoretical analyses in the classroom. Collective discussion of proper resolution methods.
  - AD3: Realization of a paper involving research and processing of information relating to Materials Science and Technology.
- **Rated activities (AE):**
  - AE1: Mid-term exam about theoretical concepts.
  - AE2: 1st control about theoretical concepts.
  - AE3: Rated exercises made in the classroom.
(ENG) - Fallo de los materiales y rotura

Learning time: 25h
- Theory classes: 4h
- Laboratory classes: 4h
- Guided activities: 2h
- Self study: 15h

Description:

- Introduction
- Fracture
  - Fundamentals of fracture
  - Ductile fracture
  - Brittle fracture
- Fatigue
  - Cyclic stresses
  - The S-N curve
  - Crack initiation
  - Crack propagation
  - Factors that affect fatigue life
- Creep
  - Creep behaviour
  - Stress and temperature effects
  - Alloys for high temperature use

Related activities:

- Guided activities:
  - AD1: Resolution of exercises and problems by the students as homework.
  - AD2: Discussion of exercises, problems and theoretical analyses in the classroom. Collective discussion of proper resolution methods.
  - AD3: Realization of a paper involving research and processing of information relating to Materials Science and Technology.

- Rated activities (AE):
  - AE1: Mid-term exam about theoretical concepts.
  - AE2: 1st control about theoretical concepts.
  - AE3: Rated exercises made in the classroom.
(ENG) - Diagramas de fases

Description:

- Introduction
- Definition and basic concepts
  - Solubility limit
  - Phases
  - Microstructure
  - Phase equilibria
- Binary phase diagrams
  - Binary isomorphous diagramas
  - Binary eutectic systems
  - Equilibrium diagramas having intermediate phases or compounds
  - Eutectic and peritectic reactions
  - Congruent phase transformations
  - The Gibbs phase rule
- The iron-carbon system
  - The iron-iron carbide phase diagram
  - Microstructure in iron-carbon alloys

Related activities:

- Guided activities:
  - AD1: Resolution of exercises and problems by the students as homework.
  - AD2: Discussion of exercises, problems and theoretical analyses in the classroom. Collective discussion of proper resolution methods.
  - AD3: Realization of a paper involving research and processing of information relating to Materials Science and Technology.

- Rated activities (AE):
  - AE3: Rated exercises made in the classroom.
  - AE5: End-of-term exam about theoretical concepts.
  - AE6: 2nd control about theoretical concepts.
### (ENG) - Transformaciones de fase

**Learning time:** 25h  
- Theory classes: 4h  
- Laboratory classes: 4h  
- Guided activities: 2h  
- Self study: 15h

### Description:

- Introduction
- Phase transformation  
  - Basic concepts  
  - The kinetics of phase transformations  
  - Multiphase transformation
- Development of microstructure and alteration of mechanical properties  
  - Transformation diagrams

### Related activities:

- **Guided activities:**  
  - AD1: Resolution of exercises and problems by the students as homework.  
  - AD2: Discussion of exercises, problems and theoretical analyses in the classroom. Collective discussion of proper resolution methods.  
  - AD3: Realization of a paper involving research and processing of information relating to Materials Science and Technology.
- **Rated activities (AE):**  
  - AE3: Rated exercises made in the classroom.  
  - AE5: End-of-term exam about theoretical concepts.  
  - AE6: 2nd control about theoretical concepts.
(ENG) - Aleaciones metálicas

### Learning time:
- Theory classes: 2h
- Laboratory classes: 2h
- Guided activities: 1h
- Self study: 7h 30m

### Description:
- Introduction
- Fabrication of metals
  - Forming operations
  - Casting
  - Miscellaneous techniques
- Metallic alloys
  - Ferrous alloys
  - Nonferrous alloys
- Thermal processing of metals
  - Annealing processes
  - Heat treatment

### Related activities:
- Guided activities:
  - AD1: Resolution of exercises and problems by the students as homework.
  - AD2: Discussion of exercises, problems and theoretical analyses in the classroom. Collective discussion of proper resolution methods.
  - AD3: Realization of a paper involving research and processing of information relating to Materials Science and Technology.
- Rated activities (AE):
  - AE3: Rated exercises made in the classroom.
  - AE5: End-of-term exam about theoretical concepts.
  - AE6: 2nd control about theoretical concepts.
**ENG - Materiales compuestos**

<table>
<thead>
<tr>
<th>Learning time: 12h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>Guided activities: 1h</td>
</tr>
<tr>
<td>Self study: 7h 30m</td>
</tr>
</tbody>
</table>

**Description:**

- Introduction
- Particle-reinforced composites
  - Large-particle composite
  - Dispersion-strengthened composites
- Fiber-reinforced composites
  - Influence of fiber length and orientation
  - Examples: carbon fiber, glass, metallic matrix, and others
- Structural composites
  - Laminar composites
  - Sandwich panels

**Related activities:**

- Guided activities:
  - AD1: Resolution of exercises and problems by the students as homework.
  - AD2: Discussion of exercises, problems and theoretical analyses in the classroom. Collective discussion of proper resolution methods.
  - AD3: Realization of a paper involving research and processing of information relating to Materials Science and Technology.

- Rated activities (AE):
  - AE3: Rated exercises made in the classroom.
  - AE5: End-of-term exam about theoretical concepts.
  - AE6: 2nd control about theoretical concepts.
### Planning of activities

<table>
<thead>
<tr>
<th>(ENG) AE1 - MID-TERM EXAM</th>
<th>Hours: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
</tr>
</tbody>
</table>

**Description:**
- As part of their individual assessment, the students will perform a mid-term exam (AE1) about theoretical concepts. This exam will be 1.5h duration. In this exam it will be evaluated the first part of the course as detailed in the contents/syllabus section.
- Each exam consists of multiple choice questions and problems related to the theoretical and experimental topics addressed in the classroom and in the laboratory. The test on one side and the problems on the other contribute a 50% of the global mark of the exam.

**Support materials:**
- Calculator and additional documentation provided during the tests/exams.

**Descriptions of the assignments due and their relation to the assessment:**
- Verification by the faculty of self-learning and profiting of guided activities realized by the student.
- The results are involved in the proposed overall mark. This exam contributes about 25% of the global mark subject.

<table>
<thead>
<tr>
<th>(ENG) AE2 - HANDS-ON ACTIVITY WITH UNIVERSAL TESTING MACHINE (UTM)</th>
<th>Hours: 1h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laboratory classes: 1h</td>
</tr>
</tbody>
</table>

**Description:**
- After the study of Content 1 ("Mechanical properties of metallic materials") a Hands-on activity with the Universal Testing Machine (UTM) is performed.
- Attendance to this Hands-on activity with the UTM (AE4) is mandatory.

**Support materials:**
- Statement of work of hands-on activities to be performed in the laboratory.
- Mechanical samples and Universal Testing Machine (UTM) enabled in the laboratory.

**Descriptions of the assignments due and their relation to the assessment:**
- Verification by the faculty of self-learning and profiting of guided activities realized by the student.
- Students have to perform in group a detailed report on the practice.
- The results are involved in the proposed overall mark. The final report contributes 5% of the global mark subject.

<table>
<thead>
<tr>
<th>(ENG) AE3 - RATED PROBLEMS REALIZED IN CLASS-TIME</th>
<th>Hours: 10h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Laboratory classes: 10h</td>
</tr>
</tbody>
</table>

**Description:**
- Students will solve exercises and problems in groups on the subject and contents of the course.
- Students will be supervised and helped by the teacher.
Support materials:
- It is allowed any material that can help students to solve exercises and problems.

Descriptions of the assignments due and their relation to the assessment:
- Attendance to this hands-on activity is mandatory.

(ENG) AE4 - HANDS-ON ACTIVITY WITH HARDNESS TESTER
Description:
- HANDS-ON ACTIVITY WITH HARDNESS TESTER.
- Support materials:
  - Statement of work describing the paper.
- Descriptions of the assignments due and their relation to the assessment:
  - Verification by the faculty of self-learning and profiting of guided activities realized by the student.
  - The rating of the report corresponds to a 10% to the global mark.

(ENG) AE5 - END-OF-TERM EXAM
Description:
- As part of their individual assessment, the students will perform an end-of-term exam (AE5) about theoretical concepts. The exam will be 1.5h duration. In this second exam it will be evaluated the second part of the course, as detailed in the contents/syllabus section.
- This exam consists of multiple choice questions and problems related to the theoretical and experimental topics addressed in the classroom and in the laboratory. The test on one side and the problems on the other contribute a 50% of the global mark of the exam.
Support materials:
- Calculator and additional documentation provided during the tests/exams.
Descriptions of the assignments due and their relation to the assessment:
- Verification by the faculty of self-learning and profiting of guided activities realized by the student.
- The results are involved in the proposed overall mark. This exam contributes about 25% of the global mark subject.
The final mark of the course (rating over 10), CF, is obtained as follows:

\[
CF = 0.325 \ AE_1 + 0.325 \ AE_5 + 0.1 \ AE_2 + 0.1 \ AE_4 + 0.1 \ AE_3 + 0.05 \ AE_6
\]

where:

- **AE1**: mid-term exam rating 32.5%
- **AE2**: rating of report on hands-on activity with the UTM 10%
- **AE3**: rating of exercises solved in the classroom 10%
- **AE4**: rating of report on hands-on activity with hardness tester 10%
- **AE5**: end-of-term exam rating 32.5%
- **AE6**: rating of attitude and participation 5%

### Qualification system

### Regulations for carrying out activities

- To be able to perform the activities it is necessary to have the proper material previously provided by the faculty.
- Attendance to the hands-on activity with the UTM (AE2) and the hardness tester (AE4) is mandatory, and it is important to comply with the basic safety and hygiene recommendations in the laboratory.
- The due dates (submission deadlines) of the corresponding rated activities consisting on deliverables (AE2, AE3 and AE4) shall be notified to students at the beginning of the course. Delays in the delivery date will result in a penalty on the mark for each activity.
Bibliography

Basic:


Complementary:


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
Hyperlink
atenea.upc.edu