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: 2017

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

Chemistry basics concepts:

Understand the relationship between electronic structure and periodic properties of elements. Know the main characteristics as well as material physical and chemical properties based on their atomic structure and the interatomic bonds. Identify the different crystal lattices in solid materials and the imperfections present therein. Explain the solid-solid diffusion and its dependence with temperature. Identify potential industrial applications of the solid-solid diffusion. Know optimization techniques and change in materials properties. Materials selection according to their operational margins. Understand the impact of several manufacturing processes in materials properties. Explain the corrosion process and identify substances potentially corrosive, based on their chemical behaviour. Understand the impact of the corrosion phenomenon in the aircraft industry. Explain the combustion process and identify substances that can be used as fuel in the Aerospace Sector.

Requirements

Prerequisite:
- Have completed knowledge in Physics fundaments.
- Have completed knowledge in Calculus.
- Have completed knowledge in Chemistry.
- Have completed knowledge in Thermodynamics.

Degree competences to which the subject contributes
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.
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- Identify and define the relationship between a material microstructure and its mechanical properties.
- Identify and define the applications of an 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></th>
<th>Total learning time: 150h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group:</td>
<td>26h</td>
</tr>
<tr>
<td>Hours medium group:</td>
<td>26h</td>
</tr>
<tr>
<td>Hours small group:</td>
<td>0h</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>14h</td>
</tr>
<tr>
<td>Self study:</td>
<td>84h</td>
</tr>
</tbody>
</table>
## Content

### (ENG) - Propiedades mecánicas de los materiales metálicos

<table>
<thead>
<tr>
<th>Learning time: 25h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td>Guided activities: 2h</td>
</tr>
<tr>
<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

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
</table>
| · Introduction  
  · Fracture  
    o Fundamentals of fracture  
    o Ductile fracture  
    o Brittle fracture  
  · Fatigue  
    o Cyclic stresses  
    o The S-N curve  
    o Crack initiation  
    o Crack propagation  
    o Factors that affect fatigue life  
  · Creep  
    o Creep behaviour  
    o Stress and temperature effects  
    o Alloys for high temperature use |

<table>
<thead>
<tr>
<th>Related activities:</th>
</tr>
</thead>
</table>
| · Guided activities:  
  o AD1: Resolution of exercises and problems by the students as homework.  
  o AD2: Discussion of exercises, problems and theoretical analyses in the classroom. Collective discussion of proper resolution methods.  
  o AD3: Realization of a paper involving research and processing of information relating to Materials Science and Technology. |
| · Rated activities (AE):  
  o AE1: Mid-term exam about theoretical concepts.  
  o AE2: 1st control about theoretical concepts.  
  o AE3: Rated exercises made in the classroom. |
### (ENG) - Diagramas de fases

<table>
<thead>
<tr>
<th>Learning time: 25h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td>Guided activities: 2h</td>
</tr>
<tr>
<td>Self study : 15h</td>
</tr>
</tbody>
</table>

### Description:
- Introduction
- Definition and basic concepts
  - Solubility limit
  - Phases
  - Microstructure
  - Phase equilibria
- Binary phase diagrams
  - Binary isomorphous diagrams
  - Binary eutectic systems
  - Equilibrium diagrams 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.
# 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: 12h 30m
  Theory classes: 2h
  Laboratory classes: 2h
  Guided activities: 1h
  Self study: 7h 30m

Description:

· Introduction
· Fabrication of metals
  o Forming operations
  o Casting
  o Miscellaneous techniques
· Metallic alloys
  o Ferrous alloys
  o Nonferrous alloys
· Thermal processing of metals
  o Annealing processes
  o Heat treatment

Related activities:

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

· Rated activities (AE):
  o AE3: Rated exercises made in the classroom.
  o AE5: End-of-term exam about theoretical concepts.
  o AE6: 2nd control about theoretical concepts.
(ENG) - Materiales compuestos

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:
- 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. The overall computation of all sets of exercises contributes 10% of the total mark subject.

### (ENG) AE4 - HANDS-ON ACTIVITY WITH HARDNESS TESTER

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>· HANDS-ON ACTIVITY WITH HARDNESS TESTER.</td>
</tr>
<tr>
<td>· Attendance to this hands-on activity is mandatory.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Support materials:</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Statement of work describing the paper.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Verification by the faculty of self-learning and profiting of guided activities realized by the student.</td>
</tr>
<tr>
<td>· The rating of the report corresponds to a 10% to the global mark.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1h</td>
</tr>
<tr>
<td>Laboratory classes: 1h</td>
</tr>
</tbody>
</table>

### (ENG) AE5 - END-OF-TERM EXAM

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>· 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.</td>
</tr>
<tr>
<td>· 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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Support materials:</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Calculator and additional documentation provided during the tests/exams.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Descriptions of the assignments due and their relation to the assessment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Verification by the faculty of self-learning and profiting of guided activities realized by the student.</td>
</tr>
<tr>
<td>· The results are involved in the proposed overall mark. This exam contributes about 25% of the global mark subject.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours:</th>
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</thead>
<tbody>
<tr>
<td>2h</td>
</tr>
<tr>
<td>Theory classes: 2h</td>
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</tbody>
</table>

### (ENG) AE6 - ATTITUDE AND PARTICIPATION

<table>
<thead>
<tr>
<th>Hours:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1h</td>
</tr>
<tr>
<td>Self study: 1h</td>
</tr>
</tbody>
</table>
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**Description:**
- Subjective assessment of the attitude and participation of the students by the faculty

**Support materials:**
- All the material delivered throughout the course

**Descriptions of the assignments due and their relation to the assessment:**
- Non applicable

**Specific objectives:**
- Evaluate the progress and implication of the students in the learning process of the subject

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**Qualification system**

The final mark of the course (rating over 10), CF, is obtained as follows:

\[
CF = 0.325 \times AE1 + 0.325 \times AE5 + 0.1 \times AE2 + 0.1 \times AE4 + 0.1 \times AE3 + 0.05 \times AE6
\]

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%

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**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:

- Presentations in the classroom by the teacher.
- Series of problems and exercises.
- Multimedia material from the Internet.
- Statement of work of hands-on activities to be performed in the laboratory.
- Statement of work describing the paper.

Hyperlink

atenea.upc.edu