# 240EM146 - Modelling of Plastic Deformation

**Coordinating unit:** 295 - EEBE - Barcelona East School of Engineering  
**Teaching unit:** 702 - CMEM - Department of Materials Science and Metallurgy  
**Academic year:** 2018  
**Degree:** MASTER'S DEGREE IN MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Teaching unit Optional)\nERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Teaching unit Optional)\nERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Teaching unit Optional)\nERASMUS MUNDUS MASTER'S DEGREE IN ADVANCED MATERIALS SCIENCE AND ENGINEERING (Syllabus 2009). (Teaching unit Optional)\nMASTER'S DEGREE IN MATERIALS SCIENCE AND ENGINEERING (Syllabus 2014). (Teaching unit Optional)  
**ECTS credits:** 4,5  
**Teaching languages:** Spanish, English

## Teaching staff

**Coordinator:** Ferhun Cem CANER  
**Others:** Ferhun Cem CANER

## Opening hours

**Timetable:** Tuesdays and Thursdays from 18h30 to 20h00

## Prior skills

Having studied the basic subjects of Science and Engineering of Materials: Structure and properties of the materials.

## Requirements

The structure and mechanical properties of materials

## Degree competences to which the subject contributes

**Specific:**  
CEMAT7. Design, calculation and modeling aspects of materials for mechanical components, structures and equipment.  
CEMAT2. Design and develop products, processes, systems and services, as well as the optimization of other already developed, based on the selection of materials for specific applications.

## Teaching methodology

The contents of this course, with a strong emphasis on practical application, are developed in classes that combine the theoretical explanation by the professor and its practical application, using a computer (provided by the student) and a commercial FEA program. Many examples illustrating the concepts studied are solved by applying different models of mechanical behavior of the engineering materials of interest.

## Learning objectives of the subject

To understand the different models of plastic and elasto-plastic behaviour of Engineering Materials.
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-To learn strategies of the numerical simulation of forming processes.
-To learn advantages and disadvantages of different formulations of plasticity in the simulation of the plastic behavior of metals.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Total learning time: 112h 30m</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours large group: 27h 24.00%</td>
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<tr>
<td></td>
<td>Hours medium group: 0h 0.00%</td>
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<tr>
<td></td>
<td>Hours small group: 13h 30m 12.00%</td>
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<tr>
<td></td>
<td>Guided activities: 0h 0.00%</td>
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<tr>
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<td>Self study: 72h 64.00%</td>
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## Content

### 1. INTRODUCTION TO THE THEORY OF ELASTOPLASTICITY

**Description:**
Mechanics of Materials.
Methods for solving plastic deformation problems.

**Related activities:**
A.1. A numerical simulation exercise of a simple case of elastic and elastoplastic deformation in 1D.

**Specific objectives:**
Introduction to the physical/mathematical modeling of plasticity and its implementation in commercial numerical simulation programs.

**Learning time:** 20h
- Practical classes: 7h
- Laboratory classes: 3h
- Self study: 10h

### 2. ELEMENTS OF THE THEORY OF PLASTICITY

**Description:**
2.1. Yield criteria.
2.2. Plastic and elastoplastic stress-strain relationship.
2.3. Non-linear phenomena.

**Related activities:**
A.2. Analysis of an isothermal forging / extrusion process by numerical simulation.

**Specific objectives:**
To understand the concept of plastic yield and its conditions, as well as stress-strain relationships that represent the plastic deformation behavior of metallic materials.

**Learning time:** 17h
- Practical classes: 4h
- Laboratory classes: 3h
- Self study: 10h
### 3. ANISOTROPY AND PLASTIC DEFORMATION OF PLANE METALLIC PRODUCTS DURING THEIR COLD WORKING.

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 16h</th>
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<tbody>
<tr>
<td>3.1. Anisotropy and microstructure. Coefficients of anisotropy.</td>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>3.2. Deep drawing. Effect of the material.</td>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td>3.3. Theory of anisotropic plasticity: Hill's criterion.</td>
<td>Self study: 10h</td>
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</tbody>
</table>

**Related activities:**

**Specific objectives:**
To understand the effect of the anisotropy of the structure of the material on its mechanical behavior.

### 4. MODELLING OF THE PLASTIC DEFORMATION USING MULTIPLE YIELD SURFACES

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 18h</th>
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<tbody>
<tr>
<td>4.1. Conceptual description and microstructure of the hardening mechanisms in view of families of compact planes.</td>
<td>Practical classes: 4h</td>
</tr>
<tr>
<td>4.2. Physical / mathematical modelling of the hardening mechanisms by taking into account the families of compact planes.</td>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td>4.3. Practical applications to the modeling of forming processes and to other plastic deformation processes.</td>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>

**Related activities:**
A.5. Simulation of the Vertex effect.

**Specific objectives:**
To understand the mechanisms of deformation and microstructural changes of metallic materials subjected to plastic deformation taking into account the families of compact planes. Mechanical behavior models and their implementation in FEM calculation programs for this purpose.
## 5. DUCTILE FRACTURE IN METALS

<table>
<thead>
<tr>
<th>Description</th>
<th>Learning time: 15h</th>
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<tbody>
<tr>
<td></td>
<td>Practical classes: 2h</td>
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<tr>
<td></td>
<td>Laboratory classes: 3h</td>
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<td>Self study : 10h</td>
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### Description:
- 5.1. Ductile fracture in metals that follows cold work hardening.
- 5.3. Examples of numerical simulation of the process of cracking in ductile metals.

### Related activities:

### Specific objectives:
To understand the deformation behavior of materials that causes failure due to cracking in ductile metals, the physical / mathematical models that represent it and its implementation in numerical calculation programs.

## 6. MECHANICAL BEHAVIOUR, MODELLING AND SIMULATION OF ELASTOMERIC MATERIALS.

<table>
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<tr>
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<td></td>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study : 10h</td>
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</tbody>
</table>

### Description:
- 6.1. Description and classification of basic elastomers.
- 6.2. Mechanical behavior of elastomeric materials.
- 6.3. Modeling and numerical simulation of elastomeric materials.

### Related activities:
- A.7. Simulation of the mechanical behavior of an elastomeric specimen.

### Specific objectives:
To understand the mechanical, static and dynamic behavior of elastomeric materials, the models that can represent such behavior and the associated simulation strategies.

## Qualification system

The qualification of the subject is constituted by the following contributions:
- 15%: The grade reflecting an active attendance to the classes.
- 35%: The average grade of the reports of the activities presented (from A.1 to A.7).
- 50%: The grade of the final project report (A.8).

## Regulations for carrying out activities

Original work developed individually or in groups according to the problem statement.
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Bibliography

Basic:


Complementary:


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Others resources:

Computer material
programa de càlcul FEM ABAQUS-student edition
ABAQUS student edition software