Degree competences to which the subject contributes

Specific:
8228. Knowledge of and competence in the application of advanced structural design and calculations for structural analysis, based on knowledge and understanding of forces and their application to civil engineering structures. The ability to assess structural integrity.

Transversal:
8559. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results among socio-economic agents involved in research, development and innovation processes.
8560. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
8561. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
250439 - MODNUMECE - Numerical Models in Civil and Structural Engineering

Teaching methodology

The course consists of 1.5 hours per week of classroom activity (large size group) and 0.8 hours weekly with half the students (medium size group).

The 1.5 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.

The 0.8 hours in the medium size groups is devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

The rest of weekly hours devoted to laboratory practice.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

Learning objectives of the subject

Specialization subject in which knowledge on specific competences is intensified.

Knowledge and skills at specialization level that permit the development and application of techniques and methodologies at advanced level.

Contents of specialization at master level related to research or innovation in the field of engineering.

This course aims to give an overview about the possibilities offered by the numerical simulation in civil engineering. The student will be able to study different topics including the structural analysis and particularly the shape optimization, the transient analysis (thermal and thermo-mechanical problems) and finally the nonlinear analysis. The necessary knowledge will be reviewed and the appropriate tools (software, interface, etc..) will be made available. To carry out the different tasks, the student will have maximum freedom solving the problems proposed and searching for the best solution in each case.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Theory classes: 19h 30m</th>
<th>15.60%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Practical classes:</td>
<td>9h 45m</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes:</td>
<td>9h 45m</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>6h</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>80h</td>
</tr>
</tbody>
</table>

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## Content

<table>
<thead>
<tr>
<th><strong>Introduction</strong></th>
<th><strong>Learning time:</strong> 2h 24m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study : 1h 24m</td>
</tr>
</tbody>
</table>

**Brief review of Continuum Mechanics**

<table>
<thead>
<tr>
<th><strong>Learning time:</strong> 12h</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 5h</td>
</tr>
<tr>
<td>Self study : 7h</td>
</tr>
</tbody>
</table>

**Description:**
Review of concepts and definitions in Continuum Mechanics
Review of the theory of elasticity and elastic problem definition

<table>
<thead>
<tr>
<th><strong>Geometric modeling and meshing</strong></th>
<th><strong>Learning time:</strong> 9h 36m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Practical classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study : 5h 36m</td>
</tr>
</tbody>
</table>

**Description:**
Downloading and installing GiD for pre-processing (CAD data) and post processing (results).
Guided tutorial for geometric modeling (GID).
Guided tutorial for finite element meshing

<table>
<thead>
<tr>
<th><strong>Structural Analysis</strong></th>
<th><strong>Learning time:</strong> 19h 12m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 3h</td>
</tr>
<tr>
<td></td>
<td>Laboratory classes: 3h</td>
</tr>
<tr>
<td></td>
<td>Self study : 11h 12m</td>
</tr>
</tbody>
</table>

**Description:**
Tutorial guide on using the software interface for structural analysis with FEM (COMET).
Tutorial on Post-Processing (GID).
Description of the different failure criteria for ductile and brittle materials.
### Transient Analysis

**Learning time:** 19h 12m  
- Theory classes: 3h  
- Practical classes: 2h  
- Laboratory classes: 3h  
- Self study: 11h 12m

**Description:**
- Thermal and thermo-mechanical problems.  
- Case studies: the numerical simulation of casting and welding processes.  
- Tutorial guide to the software interface for thermo-mechanical FEM analysis (COMET).  
- Guided exercises to solve thermal and thermo-mechanical problems.

### Nonlinear analysis

**Learning time:** 31h 12m  
- Theory classes: 7h  
- Practical classes: 3h  
- Laboratory classes: 3h  
- Self study: 18h 12m

**Description:**
- Computational methods for nonlinear analysis.  
- Numerical techniques for nonlinear analysis: Newton-Raphson, Picard, arc length, prediction techniques, etc...  
- Elasto-plasticity and elasto-damage constitutive equations for the most common materials in civil engineering (steel, concrete, soil). Yield strength, hardening and softening variables inelastic deformations and damage.  
- Tutorial on solving nonlinear problems.

### Qualification system

The evaluation consists of doing 5 assignments that correspond to the main topics covered in the course. These works can be developed in classroom and finalized at home with the delivery of a final report. It is possible to do the work individually or with another student of the course. The final mark is calculated as the average of the marks of all the works. It is mandatory to carry out all the proposed works. Otherwise, the final mark will be Not Presented (NP). In order to calculate the final mark, it is necessary to approve (marks greater than or equal to 5) all the assignments submitted.

### Regulations for carrying out activities

The assignments proposed during the course as part of the evaluation are mandatory.  
If one or more assignments are not presented the final mark will be: Not Presented (NP).
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Bibliography

Basic:


Complementary: