Degree competences to which the subject contributes

Specific:
1. MEC: Knowledge and capability for design and calculation of structures and industrial buildings.

Teaching methodology

The subject is organized in the following way:
- Theory sessions, where theoretical concepts will be developed. They will be carried out in class using expositive method. Blackboard and digital presentations will be also used.
- Practical sessions, where theoretical concepts will be applied in order to solve practical examples. They will be carried out in reduced groups in comparison with theory sessions.
- Activities, where different aspects are dealt. They are done individually or in group and at classroom or at home.

Learning objectives of the subject

The subject has two parts that coincide approximately, depending on the school calendar, with the two two-month courses:

First part: calculation of structures:
- Representing structures by using the common symbols and identifying the boundary conditions and load configurations
- Typing the analytical formulation of the internal efforts distribution (axial, shear and bending) along the structure
- Calculating the movements (displacements and rotations) at any point of a framework using the energetic theorems (Castigliano) and the formulation by Navier-Bresse
- Calculating the reactions at the supports of externally hyperstatic frameworks using the force method and the displacement method

Second part: industrial construction:
- Listing and describing the different steps in the construction process of an industrial building and the job positions that an engineer can develop in this process.
- Designing the structure of an industrial building. Identifying and describing the most common typologies of framed structures and their component elements.
- Sizing and/or checking the stress level of the structural elements of an industrial building (steel structures) accordingly with the current standard. Using the plasticity hypothesis and taking into account the instability processes.
- Analysing and interpreting the documentation which is commonly used for sizing the structural elements (codes, catalogues,)

Study load

<table>
<thead>
<tr>
<th>Total learning time: 225h</th>
<th>Hours large group: 60h 26.67%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 30h 13.33%</td>
</tr>
<tr>
<td></td>
<td>Hours small group: 0h 0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study: 135h 60.00%</td>
</tr>
</tbody>
</table>
### Content

<table>
<thead>
<tr>
<th>Topic 01: Previous knowledge</th>
<th>Learning time: 8h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 4h</td>
</tr>
</tbody>
</table>

**Related activities:**
- Activity 01.1: Theoretical session about modulus 01
- Activity 01.2: Problems resolution about modulus 01

<table>
<thead>
<tr>
<th>Topic 02: Deformed beam.</th>
<th>Learning time: 14h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td></td>
<td>Self study: 8h</td>
</tr>
</tbody>
</table>

**Related activities:**
- Activity 02.1: Theoretical session about modulus 02
- Activity 02.2: Problems resolution about modulus 02
## Topic 03: Elastic Equations.

**Learning time:** 10h  
- Theory classes: 3h  
- Practical classes: 1h  
- Self study: 6h  

**Description:**  
- a) Introduction.  
- b) Formulation.  

**Related activities:**  
- Activity 03.1: Theoretical session about modulus 03  
- Activity 03.2: Problems resolution about modulus 03

## Topic 04: Energy deformation.

**Learning time:** 17h  
- Theory classes: 5h  
- Practical classes: 2h  
- Guided activities: 10h  

**Description:**  
- a) Introduction.  
- b) Clapeyron formula.  
- c) Rayleigh-Betti theorem.  
- d) Maxwell's theorem.  
- e) Energy of deformation.  
- f) Theorems of Castigliano.  
- g) Unit force method.  

**Related activities:**  
- Activity 04.1: Theoretical session about modulus 04  
- Activity 04.2: Problems resolution about modulus 04
<table>
<thead>
<tr>
<th>Topic 05: Compatibility method</th>
<th>Learning time: 19h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 5h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>

**Description:**
- a) Basis of the method.
- b) Calculation of one-dimensional hyperstatic structures using the compatibility method.
- c) Continuous beams: formula of the three moments.
- d) Calculation of two-dimensional hyperstatic structures using the compatibility method.

**Related activities:**
- Activity 05.1: Theoretical session about modulus 05
- Activity 05.2: Problems resolution about modulus 05

<table>
<thead>
<tr>
<th>Topic 06: Equilibrium method</th>
<th>Learning time: 19h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 5h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>

**Description:**
- a) Basis of the method.
- b) Calculation of one-dimensional hyperstatic structures using the equilibrium method.
- c) Continuous beams: formula of the three turns.
- d) Calculation of two-dimensional hyperstatic structures using the equilibrium method.

**Related activities:**
- Activity 06.1: Theoretical session about modulus 06
- Activity 06.2: Problems resolution about modulus 06

<table>
<thead>
<tr>
<th>Topic 07: Stiffness method</th>
<th>Learning time: 12h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td></td>
<td>Self study: 8h</td>
</tr>
</tbody>
</table>

**Description:**
- A) Basis of the method
- B) Case of articulated flat structures.

**Related activities:**
- Activity 07.1: Theoretical session about modulus 07
### Topic 08: Design and execution of an industrial building

**Learning time:** 6h  
- Theory classes: 2h  
- Self study: 4h

**Description:**  
- a) Steps of the industrial buildings constructive process.  
- b) Engineers in construction  
- c) Standards and construction codes

**Related activities:**  
- Activity 08.1: Theoretical session about modulus 08

### Topic 09: Urban planning

**Learning time:** 11h  
- Theory classes: 2h  
- Practical classes: 1h  
- Guided activities: 4h  
- Self study: 4h

**Description:**  
- a) Territory organisation  
- b) Urban codes

**Related activities:**  
- Activity 09.1: Theoretical session about modulus 09  
- Activity 09.2: Problems resolution about modulus 09  
- Complementary activity

### Unit 10: Typology of an industrial building.

**Learning time:** 9h  
- Theory classes: 2h  
- Practical classes: 1h  
- Guided activities: 2h  
- Self study: 4h

**Description:**  
- a) Vocabulary and terminology.  
- b) Structural functions.  
- c) Typologies of frames.  
- d) Metal profile.

**Related activities:**  
- Activity 10.1: Theoretical session about modulus 10  
- Activity 10.2: Problems resolution of modulus 10  
- Complementary activity
### Topic 11: Introduction to metallic structures.

**Learning time:** 15h  
Theory classes: 4h  
Practical classes: 1h  
Guided activities: 2h  
Self study: 8h

**Description:**  
a) Metal structures: advantages and disadvantages  
b) Phases of construction.  
c) The material: steel.

**Related activities:**  
Activity 11.1: Theoretical session about modulus 11  
Activity 11.2: Problems resolution about modulus 11  
Complementary activity

### Topic 12: Projection and calculation of steel structures.

**Learning time:** 17h  
Theory classes: 4h  
Practical classes: 3h  
Guided activities: 2h  
Self study: 8h

**Description:**  
a) General.  
b) Project bases: execution classes  
c) Limit State Design  
d) Loads

**Related activities:**  
Activity 12.1: Theoretical session about modulus 12  
Activity 12.2: Problems resolution about modulus 12  
Complementary activity
### Topic 13: Serviceability Limit State (SLS)

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Bases.</td>
</tr>
<tr>
<td>b) Vertical deformation.</td>
</tr>
<tr>
<td>c) Horizontal deformations.</td>
</tr>
</tbody>
</table>

**Related activities:**
- Activity 13: Theoretical session about modulus 13
- Complementary activity

**Learning time:** 9h
- Theory classes: 2h
- Practical classes: 1h
- Guided activities: 2h
- Self study: 4h

---

### Topic 14: Ultimate Limit State (ULS).

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Concept of plastic hinge.</td>
</tr>
<tr>
<td>b) Buckling and dent.</td>
</tr>
<tr>
<td>c) Classification of sections</td>
</tr>
<tr>
<td>d) Strength of sections.</td>
</tr>
</tbody>
</table>

**Related activities:**
- Activity 14.1: Theoretical session about modulus 14
- Activity 14.2: Problems resolution about modulus 14
- Complementary activity

**Learning time:** 39h
- Theory classes: 10h
- Practical classes: 5h
- Guided activities: 4h
- Self study: 20h

---

### Topic 15: Twisting.

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Generalities: balance torsion and compatibility torsion.</td>
</tr>
<tr>
<td>b) Type of torsion: uniform, warping and mixed.</td>
</tr>
<tr>
<td>c) Strength of sections.</td>
</tr>
</tbody>
</table>

**Related activities:**
- Activity 15.1: Theoretical session about modulus 15
- Activity 15.2: Problems resolution about modulus 15

**Learning time:** 14h
- Theory classes: 4h
- Practical classes: 2h
- Self study: 8h
Students' knowledge acquisition is assessed as follows:
- First examination (N.E.1): 25%
- Second examination (N.E.2): 35%
- Resolution of Problems at classroom (N.P.): 20%
- Lecturer-directed activities (N.A.C.): 20%

Final qualification (N.F.):
N.F. = 0,25*N.E.1 + 0,35*N.E.2 + 0,20*N.P. + 0,20*N.A.C.

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.
If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

Regulations for carrying out activities
- Depending on the case, lecturer-directed activities will be carried out in a group or individually.
- Lecturer-directed activities developed in class should be carried out in the specified time.
- Lecturer-directed activities developed outside class should be delivered at time specified in the wording.
Bibliography

Basic:


Complementary:


Others resources:

Profile Celsa is a program that provides access and management of a chart of hot rolled steel profiles supplied by CELSA-Compañía Española de Laminación, S.L.
http://www.celsa.com/Productos.mvc/PerfilesComercial?=Prontuario

The Computer Program of Metallic and Mixed Structures is a freely distributed tool for the analysis, calculation and design of metallic and mixed structures.
https://goo.gl/Fvktuh

The Structural Steel Instruction (EAE) aims to establish the requirements to be met by structural steel structures related to structural safety, fire safety and environmental protection, and to provide a procedure to comply with them, which affects Design, implementation and control of steel structures; All with the ultimate aim, within the framework of the structural reliability laid down in the structural Eurocodes, to ensure adequate safety.
https://goo.gl/cZlu0y

The Basic Document (DB) is designed to establish rules and procedures to meet the basic requirements of structural security.