310709 - Introduction to Structures

Coordinating unit: 310 - EPSEB - Barcelona School of Building Construction
Teaching unit: 753 - TA - Department of Architectural Technology
Academic year: 2019
Degree: BACHELOR’S DEGREE IN ARCHITECTURAL TECHNOLOGY AND BUILDING CONSTRUCTION (Syllabus 2019). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: EUSEBIO CARLOS CARBAJAL NAVARRO
Others: XAVIER FALGUERA
SUSANA PAVÓN

Prior skills
The students have to be able to:
- Get the solicitations of any section of an isostatic structure.
- Formulate the rod solicitations laws and draw the corresponding diagrams.
- Formulate the Hooke’s Law and solve simple elasticity problems.
- Determine the gravity centre of a plain surface.
- Get the intertia momentum of a plain surface regarding the main central axis.
- Define the concept of radius of gyration of a plain surface regarding an axis and calculate its value.

Requirements
Is recommended to have passed the Mecànica and Fonaments Matemàtics de l’Enginyeria subjects.

Degree competences to which the subject contributes

Specific:
1. FE-15 Aptitude for the pre-measuring, design, calculation and verification of structures and manage its materials execution.

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.
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**Teaching methodology**

The subject will be carried out during 15 weeks due to:

- 3 weekly hours of in-person classes at class (big group / total 45 hours).
- 1 weekly hour of in-person practices at class (medium groups / total 15 hours).
- 6 weekly hours of autonomous work by the students (total 90 hours).
- 6 hours destined to evaluation session (3 hours for one or more midterm exams, and 3 hours more for the final exam in non-school time).

The teaching methodology will be based, at least, in the participatory exposition class (not really in the exposition method / master class), as far as possible, in the big group classes, together with the resolution of exercises and problems encouraging the cooperative learning by means of teamwork (groups of 3 to 5 members) and the individual learning in the practices based on the delivery of problems which allow to achieve and go in depth to the learning objectives. The autonomous work of the student, including the problems, will be guided, oriented and directed during the tutorials. This methodology will have at the disposal of the students the necessary documentation (presentations, problems wordings, slides...) in the library of the school and/or the virtual campus.

**Learning objectives of the subject**

At the end of the subject, the students should be able to:

- To measure and check sections supressed to normal stress, in an elastic and linear behaviour hypothesis of the material.
- To measure and check sections supressed to tangential stress, in an elastic and linear behaviour hypothesis of the material.
- To measure the section of a rod supressed to bending, attending to the limitation of the deformation.
- Solve the equilibrium of a hiperstatic rod.
- To formulate the deformation energy.
- Determinate the plasticity of a basic section and its resilient moment.

**Study load**

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>30h</th>
<th>20.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>9h</td>
<td>6.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>21h</td>
<td>14.00%</td>
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<tr>
<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
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</tbody>
</table>
### C1: RESISTANCE OF MATERIALS

**Description:**
In this content, the students work:
- Tangential stress; Pure shear strength. Simple flexion. Pure torsion.
- Deformation by flexion: Elastic line and turn. Mohr theorems. Limitation of the deformation.
- Hiperstatic rods: Axial strength equilibrium. Simple flexion equilibrium.
- Deformation energy: Dependant on the stresses and the solicitations. Energy theorems.

**Related activities:**
There will be carried out the activities 1, 2 and the activity 4 corresponding to the practical resolution with directed learning and its continous and final evaluation individual exams.

<table>
<thead>
<tr>
<th>Learning time: 120h</th>
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<tbody>
<tr>
<td>Theory classes: 36h</td>
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<tr>
<td>Practical classes: 12h</td>
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<tr>
<td>Self study: 72h</td>
</tr>
</tbody>
</table>

### C2: PLASTICITY

**Description:**
In this content the students work:
- Breaking criteria. Ultimate limit state.
- Flexion in the elastic-plastic field: Hypothesis. Stresses and deformations. Sections.

**Related activities:**
There will be carried out a part of the activity 3 corresponding to the practical resolution with directed learning and its continous and final evaluation individual exams.

<table>
<thead>
<tr>
<th>Learning time: 30h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 9h</td>
</tr>
<tr>
<td>Practical classes: 3h</td>
</tr>
<tr>
<td>Self study: 18h</td>
</tr>
</tbody>
</table>
### A1 INDIVIDUAL PROBLEMS- CONTINUOUS EVALUATION GROUP: INTRODUCTION.

**NORMAL TENSIONS. TANGENTIAL TENSIONS. DEFORMATIONS BY BENDING (CONTENT 1).**

**Description:**
The students, in groups of 4 to 5 members, must analyze, consider and solve fundamental kind problems, previously selected by the faculty, it will be necessary the application of the specific objectives suitables of each topic. The students will work both individually and in groups. Following correction by the faculty.
In the sessions, between the delivery of the problems, the faculty will work those variables which are more significant for guarantee the learning objectives, asking for the individual intervention of the students in the board as well as orally, considering his/her work attitude.

**Support materials:**
Presentations of the contents diferentiated by topics and self-assessment exercises both test type and development type avaible in ATENEA.
Problems wordings, which include a brief description of the objectives to be achieved and the methodology to develop them.

**Descriptions of the assignments due and their relation to the assessment:**
The problems will be personally deliveried in the fixed date. Each member of the group will be responsible of the direction of a equivalent part, having influence in the evaluation of all the group.
Return, with the corresponding feedback of the faculty and general analysis in a following session, identifying and specifying those learning objectives which must be reinforced.
It represents a part of the continous evaluation (10%).

**Specific objectives:**
At the end of the practice, the students should be able to:
  . Formulate the equilibrium of a slice of a rod.
  . Identify the type of solicitations which produce normal and tangencial stresses.
  . Define the concepts of neutral axis and central core I.
  . To measure and verify sections suppressed to normal stresses in the hypothesis of an elastic and linear behaviour of the material.
  . To measure and verify sections suppressed to tangencial stresses in the hypothesis of an elastic and linear behaviour of the material.
  . To calculate the turn and the transverse shift of the section of a rod suppressed to bending.
  . To apply the Mohr theorems to the calculation of the deformations of a rod suppressed to bending.
  . To measure the section of a rod suppressed to bending, attending to the deformation limitations.

**GENERAL OBJECTIVES**
Effective oral and written communication (In the presentation of the group activity, it is necessary that the students present orally the activity among them and prepare the presentation of it for the individual intervention at class. The activity must include a brief report of this process).
Teamwork (During the course of the activity each student will work as a member of the group and for each part which compose this activity the student also will work as responsible, directing the proposal and the development of the activity).
Autonomous self-learning. (To apply the knowledge by carrying out the given activity, decide the necessary time for increasing the knowledge, including personal contributions extending the appropriate information sources).

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**Hours:** 45h
Practical classes: 7h
Self study: 38h

#### Description:
Individual realization at class of 2 to 4 questions and/or problems of introduction and normal stresses, tangential stresses and bending deformations, which reach all the learning objectives. Following correction by the faculty.

#### Support materials:
Presentation of the topics and the supplementary documentation, basically at class, school library and ATENEA. The studied problems block which configure the activity 1. Wordings of the questions and/or problems with their scale included, and a calculator, for the fulfillment of the practice.

#### Descriptions of the Assignments Due and Their Relation to the Assessment:
Resolution of the activity by the student. The professor will return it corrected in the next session, according to criteria provided during the course of the activity 1. It represents a part of the continuous evaluation (30%).

#### Specific Objectives:
At the end of the practice, the students should be able to:
- To describe the general principles of the fundamental hypothesis of the Strength of Materials and the equilibrium of a section.
- Match up the coupling solicitation-stress and stress-deformation appropriated for a point in the section.
- To measure and verify sections suppressed to normal stresses in the hypothesis of an elastic and linear behaviour of the material.
- To measure and verify sections suppressed to tangential stresses in the hypothesis of an elastic and linear behaviour of the material.
- To formulate the equation of the elastic axis of a rod suppressed to bending.
- To measure the section of a rod suppressed to bending, attending to the deformation limitations.


#### Hours: 42h
- Practical classes: 5h
- Self study: 37h

#### Description:
The students, in groups of 4 to 5 members, must analyze, consider and solve fundamental kind problems, previously selected by the faculty, it will be necessary the application of the specific objectives suitable for each topic. The students will work both individually and in groups. Following correction by the faculty. In the sessions, between the delivery of the problems, the faculty will work those variables which are more significant for guarantee the learning objectives, asking for the individual intervention of the students in the board as well as orally, considering his/her work attitude.

#### Support materials:
Presentations of the contents differentiated by topics and self-assessment exercises both test type and development type available in ATENEA. Problems wordings, which include a brief description of the objectives to be achieved and the methodology to develop them.
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**Descriptions of the assignments due and their relation to the assessment:**
The problems will be personally delivered in the fixed date. Each member of the group will be responsible of the direction of a equivalent part, having influence in the evaluation of all the group. Return, with the corresponding feedback of the faculty and general analysis in a following session, identifying and specifying those learning objectives which must be reinforced. It represents a part of the continous evaluation (10%).

**Specific objectives:**
At the end of the practice, the students should be able to:

- To formulate the equations of compatibility of the necessary deformations to calculate the reactions.
- To calculate the reactions in a hiperstatic rod.
- To apply the fixed end moment formulas for any load case.
- To formulate the deformation energy both dependant on the stresses and the working solicitations.
- To apply the energy theorems to the calculation of the movement of the nodes of an isostatic rods structure.
- To explain the differences between the elastic and the plastic method.
- To analyze the limit states, setting the basic plasticity criteria.
- To calculate the plasticity section modulus of a basic section.

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**A4 FINAL EXAM**

<table>
<thead>
<tr>
<th>Description:</th>
<th>Hours: 10h</th>
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<tbody>
<tr>
<td>Individual exam at class of 4 to 10 questions and/or problems related with the learning objectives which can require theoretical basic plans, as well as the use of teaching material utilised for the subject. (3 hours). Correction by the faculty.</td>
<td>Practical classes: 3h</td>
</tr>
<tr>
<td>Support materials:</td>
<td>Self study: 7h</td>
</tr>
<tr>
<td>Wording with scales, calculator and if it is necessary the corresponding tables/diagrams.</td>
<td></td>
</tr>
</tbody>
</table>

**Specific objectives:**
At the end of the exam, the students shoul be able to:

- To measure and verify isostatic or hiperstatic rod sections suppressed to normal and/or tangencial stresses, in the hypothesis of an elastic and linear behaviour of the material.
- To measure the section of a rod suppressed to bending, according to the deformation limitation.
- To formulate the deformation energy.
- To calculate the plasticity section modulus of a basic section.
There will be done two problems deliveries (PR1, PR2) individual-group, written exam (Pe) and a final exam (Pf), with these pertinent worths (%):

- \( Pr = (PR1 + PR2) \) (20%)
- \( Pe = Pe \) (30%)
- \( Pf = Pf \) (50%)

The final mark will be \( NF = Pr + Pe + Pf \)

The planned dates for the delivery and/or execution of each activity are:

A1, Problem delivery 1 in three midterm deliveries,
  1.1 3rd week.
  1.2 5th week.
  1.3 7th week.

A2, Realization of the exam, 8th week.

A3, Problem delivery 2 in three midterm deliveries,
  2.1 10th week.
  2.2 12th week.
  2.3 14th week.

A4, Realization of the final exam, second EPSEB schedule.

Regulations for carrying out activities

If some of the continuous evaluation activities is not done, it will be considered as non-marked. The student who does not do the final exam will be evaluated as non-presented.

Bibliography

Basic:


Complementary:

- Timoshenko, S. Resistencia de materiales. 10a ed. Madrid: Espasa Calpe, 1964-.