240054 - Continuum Mechanics

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 737 - RMEE - Department of Strength of Materials and Structural Engineering
Academic year: 2018
Degree: BACHELOR'S DEGREE IN MATERIALS ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 4,5
Teaching languages: Catalan, Spanish

Teaching staff
Coordinator: MIQUEL FERRER BALLESTER
Others: Teoria:
MIQUEL FERRER BALLESTER
XAVIER AYNETO GUBERT
JOSEP Mª PONS POBLET

Pràctiques de Laboratori:
JORDI FABREGA FREIXES
MARC MUNDET BOLÒS
JUAN JOSÉ VALLS RODRÍGUEZ
ROMÀ SUÑÉ LAGO

Opening hours
Timetable: Tuesday, wednesday and thursday from 10:00 to 12:00h

Degree competences to which the subject contributes

Specific:
11. Knowledge and capacities to apply fundaments of materials' elasticity and resistance to the behaviour of real solids.

Transversal:
1. EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making. Taking part in debates about issues related to the own field of specialization.
2. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
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Teaching methodology

Mixed theory/problems sessions: lectures and participatory self-assessment programmed activities to do in classroom and outside of it.

Lab sessions: 2h sessions, learning based in experiment. Groups of 15 people organized in teams of 3 students. Five sessions must be carried out: 1. material testing, 2. photo elasticity 3. finite element simulation. The fourth session consist of a draft presentation of the homework. Finally, in the fifth session, the teams must hand in the course work and make a presentation.

Course work: Self-learning and cooperative. The team of three people formed in the lab groups perform a small project of free design of a piece or resistant element with the help of finite element software, optimize the piece, build a prototype and test it in the lab.

Learning objectives of the subject

At the end of the course, students should be able to:
- Analyze the displacements, velocities and accelerations fields from the equations of continuum kinematics.
- Calculate and describe the strain rates and strains of continuum by tensorial algebra.
- Analyze the stress state and identify their main characteristics.
- Identify different constitutive models for continuum.
- Relate the stress and strain states for linear elastic continuum.
- Solve the elastic problem under different boundary conditions, calculating the stress and strain states at any point.
- Calculate the elastic security factor in continuous using the appropriate failure criterion. Identify the appropriate elastic failure criterion based on the nature of the material.
- Construct an appropriate numerical model using finite element method for analysing linear elastic strains and stresses. Recognizing and identifying the appropriate boundary conditions based on a real situation of any object.
- Design a simple mechanical part or element and optimizing its strength and stiffness.
- Analyze the results of finite elements simulations.
- State the basic laws of continuum dynamics.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 112h 30m</th>
<th>Hours large group: 35h</th>
<th>31.11%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group: 10h</td>
<td>8.89%</td>
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<tr>
<td></td>
<td>Guided activities: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study: 67h 30m</td>
<td>60.00%</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Content</th>
<th>Learning time: 29h</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ENG) - Continuum kinematics</td>
<td>Theory classes: 11h</td>
</tr>
<tr>
<td></td>
<td>Self study : 18h</td>
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**Description:**
Analysis of the displacements, velocities and accelerations fields, by both Lagrangian and Eulerian formulation. Deduction of the strain rate tensor and both finite or small strain tensor.

**Related activities:**
Programmed exercises 2.1 to 2.25, both in and outside the classroom.

**Specific objectives:**
- Analyze the displacement, velocity and acceleration fields from continuum kinematics equations.
- Calculate and describe the continuum strain rate and strain using the tensorial algebra.

<table>
<thead>
<tr>
<th>Learning time: 32h</th>
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<tbody>
<tr>
<td>Theory classes: 10h</td>
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<tr>
<td>Laboratory classes: 4h</td>
</tr>
<tr>
<td>Self study : 18h</td>
</tr>
</tbody>
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| (ENG) - Stress | |
|----------------|
| Learning time: 32h |

**Description:**
Definition of the stress vector, intrinsic components of stress, stress tensor, equilibrium conditions, principal stresses and directions, Mohr circles.

**Related activities:**
Programmed Exercises 3.1 to 3.12, both in and outside the classroom.

**Specific objectives:**
- Analyzing the stress state and identifying its main features.
- Representing any tensor magnitude by Mohr circles.
### Constitutive Models. Linear Elasticity

**Description:**
Constitutive equations, generalized Hooke's law, elastic failure criteria, the elastic problem, plane stress, plane strain, axisymmetry, the finite element method.

**Related activities:**
Activities 4.1 to 4.4 and 5.1 to 12.5 for both in and outside the classroom.
Guided course homework
Laboratory practice.

**Specific objectives:**
- Identifying different continuum constitutive models.
- Relate strain and stress states of linear-elastic continuum.
- Solving the elastic problem in different boundary conditions, calculating the stress and strain states at any point.
- Calculate the security factor to failure using the appropriate elastic failure criterion. Identify the appropriate failure criterion to the nature of the material.
- Build a suitable numerical model using the finite element method for the analysis of linear-elastic stresses and strains, recognizing and identifying the appropriate boundary conditions based on a real situation of any object.
- Designing a simple mechanical part or element and optimizing its stiffness and strength.
- Analyzing the results of finite elements simulations.

### Continuum Dynamics

**Description:**
Control volume, Reynolds theorem, mass, momentum, angular momentum conservation principles, work-energy theorem.

**Related activities:**
6.1 to 6.3 activities inside the classroom.

**Specific objectives:**
- Stating the basic laws of the continuum dynamics.
Planning of activities

(ENG) EXERCICIS DINS DE L'AULA

(ENG) ACTIVITATS PER ESCRIT FORA DE L'AULA

(ENG) PRACTIQUES DE LABORATORI

| Hours: 10h |
| Laboratory classes: 10h |

(ENG) COURSE WORK

| Hours: 13h |
| Self study: 13h |

Qualification system

\[ NF = 0.2 \times NEP + 0.05 \times NL + 0.15 \times NTR + 0.6 \times NEF \]

NF: FINAL MARK
NEP: MARK OF THE PARTIAL EXAM (Test of 10 questions)
NL: MARK OF THE LAB (evaluation of the three reports + homework draft)
NTR: MARK OF THE COURSE WORK
NEF: MARK OF THE FINAL EXAM (two parts, each one of them will include both problems and theoretical questions)

In the case of extraordinary reevaluation, the entire subject content will be evaluated (laboratory sessions as well). The exam will consist of two parts (each one of them will include both problems and theoretical questions). The new mark NERA will replace the marks NEP+NL+NEF, so the final reevaluation mark will be as follow: \[ NF = \frac{NTR}{0.15} + \frac{NERA}{0.85} \].

Qualification system

Regulations for carrying out activities

PARTIAL EXAM: is a test of 10 questions with 4 possible answers. An optical-mark-recognition system is used for automated correction of responses. Theory chapters 1 and 2 as well as lab practices 1 and 2 are evaluated. Wrong questions rest 0.25 points to the mark. It is just allowed to use an A4 formulary with formulas, titles and drawings (no explanations) and a calculator of basic operations (no programmable ones or with massive memory).

LABORATORY: each team of 3 people must do a report during the practices 1, 2 and 3 and which will be handed in by the end of the practice. The evaluation of these reports (0,03) and the draft presentation of the course work (0,02) represent the mark NL.

COURSE WORK: the teams of 3 people must write a complete course work report and prepare an oral presentation. The exposition and defence of this work, as well as the prototype testing, represent the last session of the laboratory. The oral exposition, the result of the testing and the global report are evaluated by two professors and constitute the mark NTR.

FINAL EXAM: consists of two 1h-long parts, including either theoretical questions or numerical exercises without distinction. It is only allowed to use an A4 formulary with formulas, titles and drawings (no explanations) and basic calculator (no programmable ones nor with massive memory).

REPEAT STUDENTS: NL and NTR grades can be kept by signing up ONLY to the theory group (10, 20, 30...) and NOT to any laboratory subgrup (11, 12, 21, 22...), otherwise, Lab sessions and Course Work will be carried out again.
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Bibliography

Basic:


Complementary:


Others resources:

Hyperlink

http://mmc.etseib.upc.edu/index.swf

Computer material

ANSYS Educational