Course guide
240742 - 240742 - Continuum Mechanics

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 737 - RMEE - Department of Strength of Materials and Structural Engineering.
Degree: BACHELOR’S DEGREE IN INDUSTRIAL TECHNOLOGIES AND ECONOMIC ANALYSIS (Syllabus 2018).
(Compulsory subject).
Academic year: 2022   ECTS Credits: 4.5   Languages: English

LECTURER

Coordinating lecturer: MIQUEL FERRER BALLESTER
Others: Teoria:

TEACHING METHODOLOGY

Mixed theory/problems sessions: regular lectures and participatory self-assessment programmed activities during and out of the class time. An undefined number of scoring pop quizzes are also included.

Lab sessions: 2h sessions, experience-based learning. Groups of 15 people are organized into 3-student teams. Five sessions must be carried out: 1. Material testing, 2. Photo elasticity, 3. Finite element simulation, session 4 consists of the draft presentation of the course project, and session 5 consists of the final presentation and report submission of the course project.

Course project: 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 a resisting 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 fields of displacements, velocities and accelerations of the continuum, as well as their gradients, from the equations of continuum kinematics.
- Calculate and describe strains and strain rates 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 safety 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. Recognize and identifying the appropriate boundary conditions based on a real situation of any object.
- Design a simple mechanical part or element and optimize its strength and stiffness.
- Analyze the results of finite elements simulations.
- State the basic laws of continuum dynamics.
STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>35.0</td>
<td>31.11</td>
</tr>
<tr>
<td>Self study</td>
<td>67.5</td>
<td>60.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>10.0</td>
<td>8.89</td>
</tr>
</tbody>
</table>

Total learning time: 112.5 h

CONTENTS

**Continuum kinematics**

**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.

**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.

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

**Full-or-part-time:** 29h
Theory classes: 11h
Self study: 18h

**Stress State**

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

**Specific objectives:**
- Analyzing the stress state and identifying its main features.
- Representing any tensor magnitude by Mohr circles.
- Calculate the elastic safety factor of a mechanical component, using the appropriate failure criterion according to the nature of the material behaviour (brittle/ductile).

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

**Full-or-part-time:** 32h
Theory classes: 10h
Laboratory classes: 4h
Self study: 18h
Constitutive Models. Linear Elasticity

**Description:**
Constitutive equations, the principles of virtual work and power, generalized Hooke's law, the elastic problem, plane stress, plane strain, axisymmetry, the finite element method.

**Specific objectives:**
- Identify different continuum constitutive models.
- Relate strain and stress states of linear-elastic continuum.
- Solve the elastic problem in different boundary conditions, calculating the stress and strain states at any point.
- Build a suitable numerical model using the finite element method for the analysis of linear-elastic stresses and strains, recognize and identify the appropriate boundary conditions based on a real situation of any object.
- Design a simple mechanical part or element and optimize its stiffness and strength.
- Analyze the results of finite elements simulations.

**Related activities:**
Activities 4.1 to 4.4 and 5.1 to 12.5 for both within and outside the classroom.
Guided coursework.
Laboratory practices.

**Full-or-part-time:** 44h 30m
Theory classes: 15h
Laboratory classes: 4h
Self study : 25h 30m

Continuum Dynamics

**Description:**
Control volume, Reynolds' theorem, mass, momentum, angular momentum conservation principles, the principles of virtual work and power.

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

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

**Full-or-part-time:** 7h
Theory classes: 1h
Self study : 6h

**GRADING SYSTEM**

\[
FM = 0,2*MT+0,1*PQ+0,2*LAB+0,5 FE
\]

FM: FINAL MARK
MT: MID-TERM EXAM MARK
PQ: POP-UP QUIZZES MARK
LAB: LABORATORY MARK (5 lab sessions)
CP: COURSE-PROJECT MARK
FE: FINAL EXAM MARK

The reevaluation exam will assess the entire subject content. The mark REAVA will replace the marks MT+FE, so the final reevaluation mark will be as follow: 
\[
NF = PQ*0,1 + LAB*0,2 + REAVA*0,7
\]
EXAMINATION RULES.

MID-TERM EXAM: Chapters 1 and 2 as well as lab sessions 1 and 2 are evaluated. Only an A4 formulary with formulas, titles and drawings (no explanations) can be used as well as a basic calculator (no programmable ones or with massive memory).

POP-UP QUIZZES: short exercises to be solved individually during the theory/problems sessions. The number of exercises, frequency, content or calendar, is not defined in advance but specified on the go by the theory professor (pop quizzes).

LABORATORY: each team of 3 people must write a report during sessions 1, 2 and 3, to be submitted within one week (2x0,01 points). Lab session 4 consists of the draft presentation of the course project (0,02 p). Lab session 5 consists of the presentation and final report submission of the course project as well as the prototype construction and testing in the laboratory. Mark NL is the sum of the five laboratory session marks.

COURSE-PROJECT: the teams of 3 people must write a complete course project report and prepare an oral presentation. The course project presentation and the prototype testing represent the last laboratory session. The oral presentation, the result of the testing and the global report are evaluated by two professors to set the mark CP.

FINAL EXAM: consists of two or three 1h-duration parts, approximately, including numerical or textual response questions, always focused on the conceptual comprehension of the subject. Only the official A4 formulary can be used as well as a basic calculator (no programmable ones nor with massive memory).

BIBLIOGRAPHY

Basic:

Complementary:

RESOURCES

Hyperlink: