

Course guide

240742 - 240742 - Continuum Mechanics

Last modified: 10/04/2024

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: 2023	ECTS Credits: 4.5	Languages: English

LECTURER

Coordinating lecturer:	MIQUEL FERRER BALLESTER
Others:	Teoria: MIQUEL FERRER BALLESTER

TEACHING METHODOLOGY

Mixed theory/problems sessions: regular lectures and participatory self-assessment programmed activities during and out of class. 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 & DIC, 3. Finite element method, 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 the continuum by tensorial algebra.
- Analyze the stress state and identify its 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 the continuum using the appropriate failure criterion. Identify the appropriate elastic failure criterion based on the nature of the material.
- Construct an appropriate numerical model using the finite element method for analysing linear elastic strains and stresses. 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 strength and stiffness.
- Analyze the results of finite element simulations.
- State the fundamental laws of continuum dynamics.



STUDY LOAD

Type	Hours	Percentage
Self study	67,5	60.00
Hours small group	10,0	8.89
Hours large group	35,0	31.11

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

$$FM = 0,2*MT+0,3*LAB+0,5*FE$$

FM: FINAL MARK

MT: MID-TERM EXAM MARK

LAB: LABORATORY MARK (5 lab sessions)

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 follows: $NF = LAB*0,3 + REAVA*0,7$

EXAMINATION RULES.

MID-TERM EXAM: Chapters 1 and 2 are evaluated, except the "Infinitesimal Transformations" chapter. Only an A4 formula sheet, including formulas, names and drawings (no explanations) and a basic calculator (no programmable ones or with massive memory) can be used.

LABORATORY: Each team of 3 must write a report on sessions 1, 2, and 3, which must be submitted within one week (2x0,2 points). Lab session 4 consists of the draft presentation of the course project (0,4 p). Lab session 5 consists of the presentation and final report submission of the course project and the prototype construction and testing in the laboratory (2 points). 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. Two professors evaluate the oral presentation, the result of the testing and the global report to set mark CP.

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

BIBLIOGRAPHY

Basic:

- Ayneto Gubert, X.; Ferrer Ballester, M. Mecánica del medio continuo en la ingeniería : teoría y problemas resueltos [on line]. Barcelona: Iniciativa Digital Politècnica, 2012 [Consultation: 09/09/2022]. Available on: <https://upcommons.upc.edu/handle/2099.3/36613>. ISBN 9788476539507.
- Mase, G.T.; G.E. Mase. Continuum mechanics for engineers. 3rd ed. Boca Raton, FL: CRC Press, 2010. ISBN 9781420085389.

Complementary:

- Vieira Chaves, Eduardo Walter. Mecánica del medio continuo : Conceptos básicos.. 3a ed. Barcelona: CIMNE, 2012. ISBN 9788494024382.
- Spencer, A.J.M. Continuum mechanics [on line]. Mineola: Dover Publications, 2004 [Consultation: 07/10/2020]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1894359>. ISBN 0486435946.

RESOURCES

Hyperlink:

- <http://mmc.etseib.upc.edu/index.swf>. Continuum mechanics web for self-learning and self-evaluation (in catalan)