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250952 - MECMEDCON - Continuum Mechanics

Coordinating unit: 250 - ETSECCPB - Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering
Academic year: 2015
Degree: ERASMUS MUNDUS MASTER'S DEGREE IN COMPUTATIONAL MECHANICS (Syllabus 2013). (Teaching unit Compulsory)
MASTER'S DEGREE IN NUMERICAL METHODS IN ENGINEERING (Syllabus 2012). (Teaching unit Compulsory)
MASTER'S DEGREE IN CIVIL ENGINEERING (RESEARCH TRACK) (Syllabus 2009). (Teaching unit Optional)
MASTER'S DEGREE IN STRUCTURAL AND CONSTRUCTION ENGINEERING (Syllabus 2009). (Teaching unit Optional)
MASTER'S DEGREE IN STRUCTURAL AND CONSTRUCTION ENGINEERING (Syllabus 2015). (Teaching unit Optional)
ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: CARLOS AGELET DE SARACIBAR BOSCH

Others: CARLOS AGELET DE SARACIBAR BOSCH

Opening hours

Timetable: Negotiable

Degree competences to which the subject contributes

Specific:

8378. Practical numerical modeling skills. Ability to acquire knowledge on advanced numerical modeling applied to different areas of engineering such as: civil or environmental engineering or mechanical and aerospace engineering or bioengineering or Nanoengineering and naval and marine engineering, etc..
8379. Knowledge of the state of the art in numerical algorithms. Ability to catch up on the latest technologies for solving numerical problems in engineering and applied sciences.
8380. Materials modeling skills. Ability to acquire knowledge on modern physical models of the science of materials (advanced constitutive models) in solid and fluid mechanics.
8382. Experience in numerical simulations. Acquisition of fluency in modern numerical simulation tools and their application to multidisciplinary problems engineering and applied sciences.
8383. Interpretation of numerical models. Understanding the applicability and limitations of the various computational techniques.
8384. Experience in programming calculation methods. Ability to acquire training in the development and use of existing computational programs as well as pre and post-processors, knowledge of programming languages ??and of standard calculation libraries.

Teaching methodology

The course consists of 0,8 hours per week of classroom activity (large size group) and 1,2 hours weekly with half the students (medium size group).

The 0,8 hours in the large size groups are devoted to theoretical lectures, in which the teacher presents the basic concepts and topics of the subject, shows examples and solves exercises.
The course consists of 40 hours of class, taught intensively over three weeks.

The classes include theory, problems and guided activities. For each subject, the necessary theoretical concepts are introduced, are presented and solved examples are presented and solved interactively some years assessable exercises aim that the student has to solve in class with personalized tutelage of Professor, and assigned assessable exercises that the student has to solve outside the classroom.

The student has a basic teaching materials for monitoring and understanding of the course: (1) the files in pdf format with the updated content of the classes; (2) video recordings of classroom lectures given during 2012-2013; basic and supplementary bibliographic references.

Learning objectives of the subject

This is a complete course in nonlinear continuum mechanics for engineers. It carries out a deep review of the fundamental concepts, including motion, deformations, strains, stresses, governing laws of balance, variational principles and an introduction to the Mechanics of solids and of fluids.

* The students will be able to understand and assimilate the foundations of the mechanics of solids, identifying the most important aspects of material modeling, and dissipation mechanisms associated with nonlinear behaviour. * They have to be able to interpret the physical meaning of the material properties and properly identify the numerical methods for the solution of problems of solid mechanics, with its application to elasticity, and learn the foundations of fluid mechanics. * The students will develop practical skills to work with tensors and formulate and develop analysis of diverse problems of solids in engineering.

* Tensor algebra (definitions, invariants, gradients, divergences,
rotational, integral theorems).
* Kinetics: deformationºº and strain (strain tensors).
* Small deformations and compatibility.
* Stress tensors.
* Governing laws
* Constitutive Laws (laws of thermodynamics, deformation energy,
elasticity)
* Boundary value problems in linear elasticity (2D)
* Introduction to plasticity (Von Mises, Tresca, Mohr, Coulomb)
* Ideal and potential flows.
* Viscous incompressible flow (with an introduction to turbulent flow)
* Learning resources:
o Holzapel, G.A., Nonlinear solid mechanics, a continuum approach for
engineering, Wiley, 2000
o Currie,

The main objectives of the course are the presentation, understanding and mastery of the basic fundamentals of nonlinear continuum mechanics and their application to solid mechanics and fluid mechanics.

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Study load

Total learning time: 125h	Theory classes:	10h	8.00%
	Practical classes:	15h	12.00%
	Laboratory classes:	15h	12.00%
	Guided activities:	5h	4.00%
	Self study:	80h	64.00%

Content

Tensor Algebra	Learning time: 9h 36m Theory classes: 1h 30m Practical classes: 1h Laboratory classes: 1h 30m Self study : 5h 36m

Description:
In this chapter, the basic notation used in the course and a comprehensive review of the main concepts of tensor algebra is introduced.

Contents:
- Introduction
- Vector Algebra
- Tensor Algebra
- Higher-order tensors
- Differential Operators
- Integral Theorems
Problems

Specific objectives:
The objectives are to introduce the tensor notation to be used in the course and do a review of tensor algebra.

Motion	Learning time: 10h 48m Theory classes: 1h 30m Practical classes: 1h 30m Laboratory classes: 1h 30m Self study : 6h 18m

Description:
This topic describes the main assumptions of the Mechanics of Continuous Media and the main concepts of non-linear kinematics of particles are introduced: equation of motion, description of materials and spatial properties of the continuum derived materials, space and convective, displacement, velocity, acceleration, trajectories, streamlines, materials and spatial surfaces and volumes material espacial.

Contents:
- Definition of Continuous Medium
- Motion equation
- Material and spatial descriptions
- Material and spatial time derivatives
- Displacement
- Velcoity
- Accelerations
- Trajectories
- Streamlines
- Material and spatial surface
- Material and spatial volume
Problems

Specific objectives:
The aim is to introduce the main concepts of nonlinear kinematics of particles.

Strains	Learning time: 16h 48m Theory classes: 2h Practical classes: 2h Laboratory classes: 3h Self study : 9h 48m

Description:
In this chapter the main aspects of nonlinear kinematics of deformation of a continuum medium are introduced.

Contents:
- Deformation gradient tensor
- Material and spatial gradient of displacements tensors
- Green-Lagrange and Almansi strain tensors
- Volumetric Strain
- Variation of the area
- Polar decomposition of the deformation gradient tensor
- Stretching
- Variation of angles
- Spatial gradient of velocity tensor
- Deformation rate and rotation rate tensors
- Material time derivative of different tensors

Problems

Specific objectives:
The aim is to introduce the main concepts and tension associated with the deformation of a continuous medium.

Infinitesimal strains	Learning time: 7h 11m Theory classes: 1h Practical classes: 1h Laboratory classes: 1h Self study : 4h 11m

Description:
This topic hypothesis under infinitesimal strains are introduced and the corresponding simplified expressions used in the context of infinitesimal deformations are obtained. The concept of compatibility equations for the infinitesimal strain tensor is also introduced.

Contents:
- Assumptions of the theory of infinitesimal deformations
- Tensor displacement gradient
- Infinitesimal strain tensor
- Variation of infinitesimal volume
- Polar decomposition
- Stretching
- Variation of angles
- Matrix notation
- Compatibility Equations
Problems

Specific objectives:
The main objectives are to introduce the hypothesis of infinitesimal deformation theory and particularizing tensors introduced in the nonlinear case, the case of infinitesimal deformations.

Stresses	Learning time: 2h 24m Theory classes: 1h Self study : 1h 24m

Description:
This topic describes the concepts of forces and stresses on a continuous medium.

Contents:
- Body forces and surface forces
- Cauchy's theorems
- Cauchy stress tensors and first Piola-Kirchhoff stress tensor
- Piola transformation and Piola identity
- Kirchhoff and second Piola-Kirchhoff stress tensors

Specific objectives:
The main objectives are to introduce the concepts of forces and stress tensors.

Balance/conservation equations	Learning time: 21h 36m Theory classes: 2h Practical classes: 4h Laboratory classes: 3h Self study : 12h 36m

Description:

This topic describes the basic principles of conservation / balance of a continuous medium are introduced, global / local shape and material / spatial. The ultimate goal is to obtain the governing equations of a problem of continuum mechanics.

Contents:
- Basic equations of conservation / balance
- Conservation of Mass
- Convective flux of a property
- Lemma of Reynols
- Reynolds Transport Theorem
- Balance of momentum
- Balance of moment of momentum
- Thermodynamics
- First law of thermodynamics. Energy Balance
- Second Law of Thermodynamics
- Thermodynamic Processes
- Governing Equations
- Uncoupled mechanical and thermal problems

Problems

Specific objectives:

The main objectives are to introduce the basic principles of conservation / balance and get in space and equipment locally, the governing equations of a problem in continuum mechanics.

Linear elasticity	Learning time: 14h 23m Theory classes: 1h Practical classes: 3h Laboratory classes: 2h Self study : 8h 23m

Description:
This topic describes the main concepts of linear elasticity are presented, leading to pose and solve the linear elastic problems.

Contents:
- Linear elastic model
- Linear Elastic Problem
- Solution of linear elastic problem
- Orthogonal curvilinear coordinates

Problems

Specific objectives:
The main objectives are to introduce the constitutive equations for linear elastic model and come to formulate and solve the linear elastic problem.

Fluid Mechanics	Learning time: 2h 24m Theory classes: 1h Self study : 1h 24m

Description:
This chapter introduces additional concepts needed to formulate a generic problem in fluid mechanics.

Contents:
- Introduction
- Constitutive Equations
- Governing Equations

Specific objectives:
The main objective is to introduce the constitutive equations for a fluid mechanics problem.

Newtonian fluids	Learning time: 10h 48m Theory classes: 1h Practical classes: 1h 30m Laboratory classes: 2h Self study : 6h 18m

Description:
In this chapter, the constitutive equation for a Newtonian fluid is introduced and the formulation and solution of a fluid dynamics problem for Newtonian fluids is shown.

content:
- Constitutive equation
- Governing Equations
- Boundary Conditions
- Orthogonal curvilinear coordinates
Problem

Specific objectives:
The main objectives are to introduce the constitutive equations for a Newtonian fluid and get to pose and solve a problem in fluid mechanics for a Newtonian fluid.

Qualification system

The course grade is obtained from the ratings of the continuous assessment (30%) and final exam (70%).

Continuous assessment: The student has to solve along the course and supervised by the professor, several exercises and problems, both in the classroom (during school hours), and beyond.

Final exam: The final exam consists of some questions and problems similar to those that have been raised and resolved in class.

Regulations for carrying out activities

Continuous assessment: Failure to perform a continuous assessment activity in the scheduled dates will result in a zero mark in that activity.

Final exam: The final exam will be an open book exam.

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Bibliography

Basic:

Gerhard A. Holzapfel. Nonlinear Solid Mechanics: A Continuum Approach for Engineering. Wiley, ISBN 13: 978-0471823193.

Complementary:

Xavier Oliver, Carlos Agelet de Saracibar. Mecánica de Medios Continuos para Ingenieros. 3ª Edición. Barcelona: Ediciones UPC, 2002. ISBN 84-8301-582-X.

Javier Bonet, Richard Wood. Nonlinear Continuum Mechanics for Finite Element Analysis. Cambridge University Press, 1997.

Oscar González. A first course in Continuum Mechanics. Cambridge Text in Applied Mechanics, 2008.

Jerry Marsden, Tom J.R. Hugues. Mathematical Foundations of Elasticty. Courier Dover Publications, 1994.

C. Truesdell, W. Noll. The Nonlinear Field Theories of Mechanics. Springer-Verlag, 1992.