Course guide
34959 - CM - Computational Mechanics

Unit in charge: School of Mathematics and Statistics
Teaching unit: 749 - MAT - Department of Mathematics.
751 - DECA - Department of Civil and Environmental Engineering.
748 - FIS - Department of Physics.

Degree: MASTER'S DEGREE IN ADVANCED MATHEMATICS AND MATHEMATICAL ENGINEERING (Syllabus 2010).
(Optional subject).

Academic year: 2023 ECTS Credits: 7.5 Languages: English

LECTURER

Coordinating lecturer: JOSE JAVIER MUÑOZ ROMERO

Others: Segon quadrimestre:
ALVARO MESEGUER SERRANO - A
JOSE JAVIER MUÑOZ ROMERO - A
ANTONIO RODRIGUEZ FERRAN - A

PRIOR SKILLS

Basic knowledge of numerical methods
Basic knowledge of partial differential equations

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. RESEARCH. Read and understand advanced mathematical papers. Use mathematical research techniques to produce and transmit new results.
2. MODELLING. Formulate, analyse and validate mathematical models of practical problems by using the appropriate mathematical tools.
3. CALCULUS. Obtain (exact or approximate) solutions for these models with the available resources, including computational means.
4. CRITICAL ASSESSMENT. Discuss the validity, scope and relevance of these solutions; present results and defend conclusions.

Transversal:
5. SELF-DIRECTED LEARNING. Detecting gaps in one’s knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one’s knowledge.
6. 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.
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
8. 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.
9. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
TEACHING METHODOLOGY

Four elements will be combined:
- Theory classes, where the main concepts will be presented.
- Practical classes with Matlab code in the computer room, with emphasis on the computational aspects.
- Lists of short assignments.
- Course projects in groups to be presented orally at the end of the course.

Students will work on the assignments and course projects individually or in groups.

LEARNING OBJECTIVES OF THE SUBJECT

The main objective is to provide a general perspective of the broad field of computational mechanics, covering both the modelling and the computational aspects. A broad range of problems is addressed: solids, fluids and fluid-solid interaction; linear and nonlinear models; static and dynamic problems. Some emphasis is put on applications in biomechanical problems. By the end of the course, the students should:

- Be able to choose the appropriate type of model for a specific simulation
- Be familiar with the mathematical objects (tensors) and differential operators used in computational mechanics
- Be aware of the different level of complexity of various problems (e.g. linear vs. nonlinear, static vs. dynamic).

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>60,0</td>
<td>32.00</td>
</tr>
<tr>
<td>Self study</td>
<td>127,5</td>
<td>68.00</td>
</tr>
</tbody>
</table>

Total learning time: 187.5 h

CONTENTS

CONTINUUM MECHANICS

Description:

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study: 21h 15m

COMPUTATIONAL ELASTICITY

Description:

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study: 21h 15m
COMPUTATIONAL DYNAMICS

Description:

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study: 21h 15m

COMPUTATIONAL PLASTICITY, FRACTURE AND VISCOELASTICITY

Description:
Basic concepts and motivation. Non-linear problems. Geometrical and material non-linearity. One-dimensional plasticity: elastic and plastic strains;
elastoplastic constitutive equation; hardening. Multi-dimensional plasticity: stress and strain invariants; yield surface; plastic flow. Numerical time-integration of the constitutive equation: elastic prediction and plastic correction; iterative methods for the plastic correction. Applications. Phase field formulation and Finite Element discretisation.

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study: 21h 15m

COMPUTATIONAL FLUID DYNAMICS

Description:

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study: 21h 15m

COMPUTATIONAL METHODS FOR WAVE PROBLEMS

Description:

Full-or-part-time: 31h 15m
Theory classes: 8h
Practical classes: 2h
Self study: 21h 15m
GRADING SYSTEM

Final exam (40%), assignment problems (30%), and course project (30%, evaluated with an oral presentation and a written report).

BIBLIOGRAPHY

Basic:

Complementary: