# Computational Engineering (250406)

## General Information

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|---|---|
| **School** | ETSECCPB |
| **Departments** | Departament d'Enginyeria Civil i Ambiental (DECA) |
| **Credits** | 6.0 ECTS |
| **Programs** | MÀSTER UNIVERSITARI EN ENGINYERIA DE CAMINS, CANALS I PORTS (pla 2012)<br>MÀSTER UNIVERSITARI EN ENGINYERIA DE CAMINS, CANALS I PORTS (pla 2012)<br>PARS: ENGINYER/A DE CAMINS, CANALS I PORTS (pla 2022) |
| **Course** | 2024/25 |

## Main teaching language at each group

- Group 10EN1 English (Q1)
- Group 10EN2 English (Q2)

## Faculty

Responsible Faculty: Antonio Rodriguez Ferran
Faculty: Antonio Rodriguez Ferran, Pablo Saez Viñas

## Objectives of Education

Students will learn to design computational models for the mechanics of continuous media and for solving diagnostic problems encountered in engineering.

Upon completion of the course, students will be able to:

Develop computational models based on mechanics of continuous media and apply them to different areas of civil engineering, including soil and rock mechanics, structural analysis, hydrology and water resources, ports and coastal systems;
Develop discrete computational models and use them for network design in different areas of civil engineering, in particular transport, logistics, power distribution and infrastructure mapping;
Apply the uncertainty principle to data on the external actions and internal properties of systems;
Apply stochastic computational models and subject the results to statistical processing;
Use the results of computational models as the basis for design, analysis, optimisation and decision-making in civil engineering.

Computational engineering techniques for the modelling and solution of continuous equilibrium and evolution problems; Application to structural engineering, geotechnical engineering, transport engineering, maritime engineering and environmental engineering; Continuous optimisation techniques (linear programming and nonlinear programming): Application to optimal design, parameter identification and resource allocation; Discrete optimisation and combinatorial optimisation techniques: Application to network design; Monte Carlo simulation: Application to decision-making in management and planning

## Competencies

### Especific

The ability to apply knowledge of soil and rock mechanics to the study, design, construction and operation of foundations, cuts, fills, tunnels and other constructions over or through land, whatever its nature and state, and whatever the purpose of the work.

Knowledge of and competence in the application of advanced structural design and calculations for structural analysis, based on knowledge and understanding of forces and their application to civil engineering structures. The ability to assess structural integrity.
The ability to plan, dimension, construct and maintain hydraulic works.
The ability to plan, evaluate and regulate the use of surface water and groundwater resources.
Knowledge of and the ability to understand dynamic phenomena of the coastal ocean and atmosphere and respond to problems encountered in port and coastal areas, including the environmental impact of coastal interventions. The ability to analyse and plan maritime works.
Knowledge of transport engineering and planning, transport types and functions, urban transport, management of public transport services, demand, costs, logistics, and financing of transport infrastructure and services.

### Transversal

ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results among socio-economic agents involved in research, development and innovation processes.
EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

## Total hours of student work

| | | Hours | Percentage |
|---|---|---|---|
| Supervised Learning | Large group | 27.96 h | 51.78 % |
| | Medium group | 13.02 h | 24.11 % |
| | Laboratory classes | 13.02 h | 24.11 % |
| | Guided Activities | 0.0 h | 0.00 % |
| Self Study | | 96.0 h | |

## Contents

### Part 1: Modelling with partial differential equations (PDE)

Unit 1: The finite volume method
Unit 2: Eigenvalue problems
Unit 3: Nonlinear problems

### Part 2: Optimització

Unit 4: Unconstrained optimization
Unit 5: Constrained optimization
Unit 6: Linear programming
Unit 7. Parameter identification
8. Combinatorial and discrete optimization

### Part 3: Decision making

Unit 9: Monte Carlo simulation and risk analysis
Unit 10: Introduction to machine learning

## Teaching Methodology

Taught module delivery: fifteen weeks of teaching, coursework and self-study. Apart from the 4 hours per week in the classroom, self-study must last an average of 6 hours per week.

Although most of the sessions will be given in the language indicated, sessions supported by other occasional guest experts may be held in other languages.

## Grading Rules

*(*) The evaluation calendar and grading rules will be approved before the start of the course.*

1. The module is graded with the following elements:
- Two tests (T1 and T2), which are strictly individual.
- Classwork (CW), to be carried out either individually or in teams.
- Homework (HW), to be carried out individually.

2. Classwork (CW) refers, among others, to:
- Participation in class discussions.
- Solution of computer tutorials in class.

3. Homework (HW) refers, among others, to:
- Solution of exercises.
- Reports.

4. Tests T1 and T2 will cover all the topics covered from the beginning of the module.

5. Academic dishonesty (including, among others, communication during tests, plagiarism and falsification of results) will be severely punished, in accordance with current academic regulations: any such act will imply a final mark of 0 in the module.

6. The final mark for the module is obtained as

Mark = 0,70*T + 0,10*CW + 0,20*HW

with T = (T1 + T2)/2

## Test Rules

Will be discussed in class.

## Office Hours

Will be announced at the beginning of the course.

## Bibliography

### Basic


- Dennis, J.E.; Schnabel, R.B. Numerical methods for unconstrained optimization and nonlinear equations. Philadelphia: SIAM, 1996. ISBN 0898713641.
- Bathe, K.J. Finite element procedures. [S. l.]: Prentice Hall, 2006. ISBN 9780979004902.
- Deuflhard, P.; Bornemann, F. Scientific computing with ordinary differential equations. New York: Springer, 2002. ISBN 0387954627.
- Donea, J.; Huerta, A. Finite element methods for flow problems. Chichester: John Wiley & Sons, 2003. ISBN 0471496669.
- Nocedal, J.; Wright, S.J. Numerical optimization. 2nd ed. Berlin: Springer, 2006. ISBN 0387303030.


### Complementary


- Belytschko, T.; Liu, W.K.; Moran, B.; Elkhodary, K.I. Nonlinear finite elements for continua and structures. 2nd ed. Chichester: Wiley, 2014. ISBN 9781118632703.
- Zienkiewicz, O.C.; Taylor, R.L.; Nithiarasu, P. The finite element method: vol. 3 for fluid dynamics. 7th ed. Amsterdam: Elsevier Butterworth-Heinemann, 2014. ISBN 9781856176354.