Course guide
250COD004 - 250COD004 - Introduction to Computational Methods

Last modified: 17/06/2026

Unit in charge: Barcelona School of Civil Engineering
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: MASTER'S DEGREE IN COMPUTATIONAL AND DATA-ASSISTED ENGINEERING (Syllabus 2026). (Compulsory subject).

Academic year: 2026 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Codony Gisbert, David

Others:

TEACHING METHODOLOGY

The course is composed of several sessions of 2 hours, combining:
- Theory lectures, with concepts, examples, and exercises.
- Hands-on sessions using computational tools and available libraries to solve engineering-oriented problems.
- Working in the course project about an engineering challenge that requires the application of numerical methods.

LEARNING OBJECTIVES OF THE SUBJECT

The course introduces the classical foundations of the numerical methods for functions, systems of equations, and ordinary differential equations, as well as the practical use of modern tools that implement them. The methods will be motivated and applied to solve a wide variety of problems in engineering, science and other fields. The course includes a project where students face an engineering challenge, and requires the application of different numerical methods.

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	36.00
Self study	80,0	64.00

Total learning time: 125 h

CONTENTS

1. Function approximation

Description:
Taylor series, Numerical Differentiation, Finite Differences, Natural basis, Lagrange Polynomials, C0/Hermite Splines, Least Squares, Moving Least Squares

Full-or-part-time: 31h 15m
Theory classes: 11h 15m
Self study : 20h

2. Numerical Integration

Description:
Newton-Cotes, Gauss-Legendre, Composite rules.

Full-or-part-time: 6h 15m
Theory classes: 2h 15m
Self study : 4h

3. Root finding of scalar equations

Description:
Bisection, Secant, Newton.

Full-or-part-time: 6h 15m
Theory classes: 2h 15m
Self study : 4h

4. Differential Equations

Description:
Initial value problem, Forward/Backward Euler, Heun, Runge Kutta, ODE45, ODE systems, High-order ODE, Phase space, Boundary value problems, Shooting method, Introduction to finite differences for BVP.

Full-or-part-time: 37h 30m
Theory classes: 13h 30m
Self study : 24h

5. Systems of Equations

Description:
Linear systems: Direct methods (LU/Cholesky), renumbering. Iterative methods (CG/GMRES), preconditioning. Nonlinear systems: Fixed-point, Newton, Quasi-Newton.

Full-or-part-time: 18h 45m
Theory classes: 6h 45m
Self study : 12h

6. Eigenvalue problems

Description:
Power/inverse power

Full-or-part-time: 6h 15m
Theory classes: 4h
Self study : 2h 15m

7. Project presentations

Description:
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Full-or-part-time: 6h 15m
Theory classes: 2h 15m
Self study : 4h

8. Exam

Description:
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Full-or-part-time: 6h 15m
Theory classes: 2h 15m
Self study : 4h

GRADING SYSTEM

1. The course is assessed based on the following elements:
* Deliverables (D), to be completed individually or in teams.
* Course project (P), to be submitted and defended individually or in teams.
* Final test (T) that is strictly individual.

2. Deliverables (D) refers to, among others:
* Classroom exercises.
* Classroom quizzes.
* Other activities.

3. The course project where consists on an engineering challenge that requires the application of different numerical methods. It must be submitted and publicly defended.

4. The contents of the final test will cover all the material taught since the beginning of the course.

5. Academic dishonesty (including, but not limited to, communication during tests, plagiarism, and falsification of results) will be severely punished in accordance with current academic regulations: any act of this nature implies a final grade of 0 in the course.

6. The final grade for the course is obtained according to:
Mark = T*0.65 + P*0.25 + D*0.1

EXAMINATION RULES.

The assignments must be sent through ATENEA respecting the announced deadline. Late submissions or assignments submitted by other means will not be accepted and will be graded 0.
Assignments must be completed individually: students are encouraged to confront each other over issues, but submitted work must be the result of their own efforts of each students. Plagiarism in homework will be penalized with a 0 in the class work grade.
The exams must be taken individually and books or class notes will not be accepted. Plagiarism during exams will be penalized with a 0 in the final grade for the subject.

Students who fail the ordinary exams will have the option to take a reassessment test within the period set by the academic calendar. Students who have already passed the subject will not be able to take the reassessment test.
The maximum grade in the case of taking the reassessment exam will be five (5.0). The non-attendance of a student summoned to the reassessment test, held within the set period, may not lead to another test at a later date.

BIBLIOGRAPHY

Basic:
- Hoffman, Joe D. Numerical methods for engineers and scientists. 2nd ed. rev. and exp. New York: CRTC Press, 2001. ISBN 0824704436.
- Burden, R.L.; Faires, J.D.; Burden, A.M. Numerical analysis. 10th ed. Boston, MA: Cengage Learning, 2016. ISBN 9781305253667.
- Quarteroni A.; Saleri, F.; Gervasio, P. Scientific computing with MATLAB and Octave [on line]. 4th ed. Heidelberg: Springer-Verlag, 2014 [Consultation: 23/06/2026]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-642-45367-0. ISBN 9783642453663.
- Recktenwald, G.W. Numerical methods with MATLAB: implementations and applications. Upper Saddle River: Prentice Hall, 2000. ISBN 0201308606.