Numerical Methods for Pdes (250950)

General Information

School	ETSECCPB
Departments	Departament d'Enginyeria Civil i Ambiental (DECA)
Credits	5.0 ECTS
Programs	MÀSTER UNIVERSITARI EN ENGINYERIA ESTRUCTURAL I DE LA CONSTRUCCIÓ (pla 2015) MÀSTER UNIVERSITARI EN MÈTODES NUMÈRICS EN ENGINYERIA (pla 2012) MÀSTER UNIVERSITARI EN MÈTODES NUMÈRICS EN ENGINYERIA (pla 2012)
Course	2024/25

Main teaching language at each group

- Group 10EN1 English (Q1)

Faculty

Responsible Faculty: Sergio Zlotnik Martinez
Faculty: Miquel Aguirre Font, Sergio Zlotnik Martinez

Objectives of Education

The course introduces the modern and classical foundations of the numerical methods for solving linear and nonlinear differential equations. It introduces its application to a wide variety of problems in science, engineering, and other fields. The subjects to treat include finite differences, finite volumes, and boundary elements. Deiiferent discretization strategies for PDEs are devised as well as a wide outline of the direct and iterative methods to solve the algebraic systems of equations. The course includes also numerical methods for the solution of the eigenvalue problem.

* The student will understand and formulate numerical procedures to solve typical problems, identifying the most suitable method for the corresponding PDE. * This includes the more relevant numerical methods for calculation and design in engineering, providing numerical approximations to boundary-value problems and initial-value problems derived from conservation equations. * The students will also develop the capacity of abstraction and synthesis, understand the structure of vectorial spaces and the concept of linearity. * The students will have to acquire independence in their studies, be able to implement and use computer programs and rationally interpret the results obtained.

* Review of the differential equations.
* Finite differences methods for elliptical equations.
* Finite differences methods for parabolic equations (including aspects of consistency, stability and convergence)
* Finite differences methods for hyperbolic equations
* Introduction to finite volumes
* Introduction to integral methods and boundary elements
* Solution techniques for:
  a. Direct methods and their implementation
  b. Iterative methods (fixed points and Krylov methods)
* Non linear problems.
* Newton-Raphson Methods.
* Quasi-Newton Methods.
* Newton-Secantes Methods.

* Numerical developments of the methods NR, QN and SN.
* One-dimensional minimisation.
* Length of arch control
* Techniques for the solution of eigenvalue problems
Learning resources:
o Class ntoes
o Hoffman, J.D., Numerical Methods for engineers and scientists, McGraw-Hill, 1992
o Smith, G.D., Numerical Solution of Partial Differential Equations, Oxford University Press,1986
o Further readings:
o Leveque, R., Numerical Methods for Conservation Laws, Lectures in Mathematics, ETH Zürich, 1992
o Vila, A.; Rodríguez-Ferran, A.; Huerta, A. Métodos numéricos para sistemas no lineales de ecuaciones.
o Iterative methods for nonlinear systems of equations: an introduction. Laboratori de Càlcul Numèric.
o Dennis, J.E.; Schnabel, R.B. Numerical methods for unconstrained optimization and nonlinear equations. Prentice-Hall Series in Computational Mathematics, 1983., Reimpreso en Classics in Applied Mathematics, SIAM, 1996.

Total hours of student work

		Hours	Percentage
Supervised Learning	Large group	25.5 h	56.67 %
	Medium group	9.75 h	21.67 %
	Laboratory classes	9.75 h	21.67 %
	Guided Activities	0.0 h	0.00 %
Self Study		80.0 h	

Contents

Basics

Foundations to numerical methods: finite arithmetics, root of functions, interpolation, solution of systems of linear equations, integration.

Specific Objectives

-
-
-

Numerical methods for ODEs

Methods for the solution of ordinary differential equations. Initial value problem, boundary value problems.

Methods for the solution of PDEs

Numerical method for the solution of partial differential equations.

Teaching Methodology

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

The 1,2 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 1,2 hours in the medium size groups is devoted to solving practical problems with greater interaction with the students. The objective of these practical exercises is to consolidate the general and specific learning objectives.

The rest of weekly hours devoted to laboratory practice.

Support material in the form of a detailed teaching plan is provided using the virtual campus ATENEA: content, program of learning and assessment activities conducted and literature.

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.

The mark of the course is obtained from the ratings of continuous assessment and their corresponding laboratories and/or classroom computers.

Continuous assessment consist in several activities, both individually and in group, of additive and training characteristics, carried out during the year (both in and out of the classroom).

The teachings of the laboratory grade is the average in such activities.

The evaluation tests consist of a part with questions about concepts associated with the learning objectives of the course with regard to knowledge or understanding, and a part with a set of application exercises.

Test Rules

Failure to perform a laboratory or continuous assessment activity in the scheduled period will result in a mark of zero in that activity.

Bibliography

Basic

- Hoffman, J.D. Numerical methods for engineers and scientists. 2nd ed. rev. and exp. New York: Marcel Dekker, 2001. ISBN 0824704436.
- Smith, G.D. Numerical solution of partial differential equations: finite difference methods. 3rd ed. Oxford: Clarendon Press, 1985. ISBN 0198596502.
- Burden, R.L.; Faires, J.D.; Burden, A.M. Numerical analysis. 10th ed. Boston, MA: Cengage Learning, 2016. ISBN 9781305253667.