COURSE DATA

DATA SUBJECT

Code: 34181
Name: Advanced numerical methods
Cycle: Undergraduate Studies
ECTS Credits: 6
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
1107 - Degree in Mathematics	Facultat de Ciències Matemàtiques	4	Second quarter

SUBJECT-MATTER

Degree	Subject-matter	Character
1107 - Degree in Mathematics	Numerical methods	ELECTIVES

COORDINATION

YAÑEZ AVENDAÑO DIONISIO FELIX

SUMMARY

This subject, located in the second semester of the fourth year of the degree, has an optional character and is taught after the subject of numerical calculation.

The purpose of this subject is to study in depth the numerical resolution of partial differential equations by means of discretizations in finite differences. The theoretical and practical difficulties involved in the proposed methods will be studied, as well as their computational complexity. Computationally efficient iterative methods will be studied for the numerical resolution of systems of linear equations that result from some discretizations of linear elliptic partial differential equations.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

COMPETENCES / LEARNING OUTCOMES

1107 - Degree in Mathematics

Ability to work in teams.

Adapting to new situations.

Capacity for analysis and synthesis.

Capacity for organization and planning.

Expressing mathematically in a rigorous and clear manner.

Knowing the time and the historical context in which occurred the great contributions of women and men in the development of mathematics.

Learn autonomously.

Participate in the implementation of software and learn mathematical software.

Reason logically and identify errors in the procedures.

Solve problems that require the use of mathematical tools.

Visualize and interpret the solutions obtained.

DESCRIPTION OF CONTENTS

1. Numerical Methods for Elliptic PDEs

- Review of methods for boundary value problems involving second-order ODEs.
- Numerical methods for two-dimensional elliptic problems.
- Stability and convergence of numerical methods for two-dimensional elliptic problems.

2. Iterative Methods for Solving Linear Systems

- Linear iterative methods: Jacobi, Gauss-Seidel, and Successive Over-Relaxation (SOR).
- Conjugate gradient method.
- Preconditioners for the conjugate gradient method.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	24,00
Other activities	6,00
Computer classroom practice	30,00
Total hours	**60,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	0,00
Independent study and work	0,00
Preparation of lessons	65,00
Preparation for assessment activities	25,00
Resolution of case studies	0,00
Total hours	**90,00**

TEACHING METHODOLOGY

The subject is structured in theoretical and practical classes. In the first ones, the basic ideas and the big strokes of the theory are given. The theoretical details that have been pointed out in the theory sessions are developed in some of the practical ones, while other practical sessions are devoted to putting into operation and analyzing the proposed numerical methods.

The exercises proposed in the theoretical-practical sessions can be done in pairs and must be written with LaTeX. For each activity that must be submitted, a period of no less than ten days will be set from the end of the last session dedicated to that activity.

EVALUATION

The student's evaluation will be done continuously throughout the course and will consist of the following blocks:

1. Evaluation of the work sent at the end of each session and reports of submitted practices (25%)

2. Presentation of some sections of the theoretical-practical activities, partially chosen by the student. In the presentation, the students' synthetic capacity and the quality of their answers will be evaluated. The material of the presentation must contain everything necessary to make the assessment of this section (theoretical contents, code, results, comments, if applicable) (65 %)

3. Participation in class and presentations (10%)

REFERENCES

- G. H. Golub y C. F. van Loan, Matrix Computations, Johns Hopkins University Press, 1996.
- J. C. Strikwerda, Finite difference schemes and partial differential equations. . Wadsworth & Brooks/Cole Advanced Books & Software, 1989.
- G. Strang, Introduction to applied mathematics. Wellesley-Cambridge Press, Wellesley, MA, 1986.

Complementary references:

- R. D. Richtmyer, K. W. Morton, Difference methods for initial-value problems. Second edition, Interscience Publishers John Wiley & Sons, Inc., 1967.
- Y. Saad, Iterative methods for sparse linear systems. Second edition. Society for Industrial and Applied Mathematics, 2003.
- J. W. Demmel, Applied numerical linear algebra. SIAM, 1997.
- S. Larsson, V. Thomée, Partial differential equations with numerical methods. Springer-Verlag, 2009.
- R. J. LeVeque, Finite difference methods for ordinary and partial differential equations. Steady-state and time-dependent problems. SIAM, 2007.