UAB Universitat Autònoma de Barcelona	Numerical Calculus Code: 104390 Credits: 6	2026/2027

Degree programme	Type	Course
Computational Mathematics and Data Analytics	FB	1

Contact lecturer

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Teaching staff

Susana Serna Salichs

Group languages

You can consult this information at the end of the document.

Prerequisites

A first course on calculus in one variable, and a first course on linear algebra.

Objectives

Modeling turns problems in science and engineering into mathematical problems. The complexity of the real world often gives rise to mathematical problems that cannot be addressed from an analytic approach. Or perhaps they can, but the analytic approach may be too complex in the context in which the solution of the problem is required. For instance, solving the problem could be part of a contract, for which limited time is available.

Numerical methods are techniques from which algorithms can be deduced in order to obtain approximate solutions of mathematical problems. Many times, especially when high precision is required, these algorithms demand a large amount of computations. The use of a computer is then mandatory. Computers are most efficient when using finite precision arithmetic (this is, working with a finite number of digits). This means that each operation introduces error, known as round-off. This is not usually a problem, in particular because we are looking for approximate solutions. Nevertheless, it is necessary to know how to avoid situations in which the propagation of round-off error could completely invalidate our computations.

This course is devoted to the analysis of basic numerical methods, related to the solution of the kind of mathematical problems studied in first-year courses. This analysis has as a goal being able to predict both the quality of the approximations produced by the different methods and the computational effort they involve. This course is also an introduction to scientific computing, this is, the set of techniques and skills needed for the implementation in a computer of the numerical solution of a problem.

The numerical methods studied in this course are building stones of numerical methods for the solution of more sophisticated problems, studied from the second year on, like ordinary and partial differential equations.

Learning outcomes

- CM05 (Design numerical, probabilistic algorithm and combinatorial algorithm solutions to solve real problems.) Design numerical, probabilistic algorithm and combinatorial algorithm solutions to solve real problems.
- KM02 (Distinguish the objects of calculus with functions and their properties and uses.) Distinguish the objects of calculus with functions and their properties and uses.
- KM03 (Describe the mathematical concepts and objects specific to numerical calculus.) Describe the mathematical concepts and objects specific to numerical calculus.
- SM04 (Relate the concepts of the calculus of a real variable with methods and objects from other fields.) Relate the concepts of the calculus of a real variable with methods and objects from other fields.
- SM05 (Develop independent strategies to solve problems specific to numerical calculus, probability and graph theory.) Develop independent strategies to solve problems specific to numerical calculus, probability and graph theory.
- SM06 (Solve problems involving integrals (lengths, areas, volumes, etc.).) Solve problems involving integrals (lengths, areas, volumes, etc.).

Contents

Error propagation

Numerical solution of non-linear equations

Interpolation, differentiation, integration

Numerical linear algebra

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Computer work	16	0.64	CM05, KM03
Theoretical sessions	30	1.2	CM05, KM02, KM03, SM04, SM05, SM06
Computer sessions	8	0.32	CM05, KM03
Personal study	76	3.04	CM05, KM02, KM03, SM04, SM05, SM06
Problem sessions	15	0.6	CM05, KM02, KM03, SM04, SM05, SM06

The theoretical sessions will be dedicated to the presentation by the lecturer of various methods and their analysis. The presentation of the methods will be accompanied by examples of their behavior aimed at both facilitating the understanding of the method and motivating its analysis.

In the problem-solving sessions, theoretical and computational problems will be solved.

The computer practice sessions will be dedicated to solving problems that will be implemented in a compiled language. In solving these problems, students will gradually build their personal library of routines that implement basic numerical methods.

Annotation: within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continuous assessment activities

Title	Weight	Hours	ECTS	Learning outcomes
Computer work	0.15	0	0	CM05, SM05, SM06
Partial exam	0.36	2	0.08	CM05, KM02, KM03, SM04, SM05, SM06
Final exam	0.49	3	0.12	CM05, KM02, KM03, SM04, SM05, SM06

The evaluation of the course will be carried out through three activities:

• Partial exam (EP): exam on part of the subject, with theoretical questions and problems.

• Final exam (EF): exam on the entire subject, with theoretical questions and problems.

• Computer practice (PR): submission of code and a report. Some practice sessions will be evaluated.

Additionally, students may take a resit examination (ER) with the same characteristics as the final exam (EF).

To pass the course, it is required that max(0.42*EP + 0.58* EF, EF, ER) ≥ 5 and that EF ≥ 5 and PR ≥ 4

The final course grade will be:

0.85 · max(0.42·EP + 0.58·EF, EF, ER) + 0.15 · PR.

Honours distinctions will be awarded in the first complete assessment of the course. They will not be withdrawn if another student obtains a higher grade after considering the ER examination.

Single assessment

Students who have opted for the single assessment modality must take a final test consisting of a theory and problem-solving exam. To take this test, they must submit, before the start of the exam, all assignments required during the course, which will be assessed through an oral examination.

To pass the course, the assignment grade must be at least 4 out of 10 and the exam grade at least 5 out of 10. The final grade will be the weighted average of both activities, where the exam accounts for 85% of the grade and the assignments 15%.

If the final grade is below 5, a new opportunity will be given to pass the course through the resit examination, which will be held on the date set by the programme coordination. In this exam, 85% of the theory grade may be recovered. The practical component is not recoverable.

The criterion for obtaining a "Not assessable" grade is as follows: a student will be considered to have participated in the course if they submit at least half of the assignments or take any of the exams (EP or EF). Otherwise, the grade will be "Not assessable".

Use of Artificial Intelligence (AI)

For this course, the use of Artificial Intelligence (AI) technologies is permitted exclusively for studying, clarifying concepts, practising, and debugging code. They may also be used to review solutions previously developed by the students themselves. It is not permitted to submit AI-generated content as one's own work or to use AI during individual assessments unless explicitly authorised. Students must be able to explain and defend any solution, algorithm, or code they submit.

Students must clearly identify which parts have been generated using this technology, specify the tools used, and include a critical reflection on how these tools have influenced both the process and the final outcome of the activity. Failure to disclose the use of AI in this assessed activity will be considered a breach of academic integrity and may result in a partial or total reduction of the grade for the activity, or more severe penalties where appropriate.

Bibliography

Basic references:

- A. Aubanell, A. Benseny, A. Delshams. Eines bàsiques de càlcul numèric. Manuals de la UAB 7, Publ. UAB, 1991.
- M. Grau, M. Noguera. Càlcul numèric. Edicions UPC, 1993.
- J.D. Faires, R. Burden. Métodos numéricos, 3a ed. Thomson, 2004.
- R. Burden, J.D. Faires. Numerical analysis, 6a ed. Brooks/Cole, 1997.
- G. Hämmerlin, K.-H. Hoffmann. Numerical mathematics. Springer, 1991.

Advanced references:

- E. Isaacson, H.B. Keller. Analysis of numerical methods. Wiley, 1966.
- J. Stoer, R. Bulirsch. Introduction to numerical analysis, 3a ed. Springer, 2002.
- G. Dahlquist, A. Björk. Numerical methods. Prentice Hall, 1964.
- A. Ralston and P. Rabinowitz. A first course in numerical analysis. McGraw-Hill, 1988.
- A. Quarteroni, R. Sacco and F. Saleri. Numerical Mathematics. Springer, 2000.

Software

- Preferably a Linux environment
- code-oriented text editor (e.g. Kate)
- GNU C compiler
- gnuplot
- image manipulation tools (e.g. imagemagick)
- GNU Octave

Course groups and languages

The information provided is provisional until November 30. After this date, you will be able to consult the language of each group through this link. To access the information, you will need to enter the course CODE

Type of teaching	Group	Language	Semester	Shift
(TE) Theory	1	Spanish	second semester	morning-mixed
(PLAB) Practical laboratories	1	Spanish	second semester	morning-mixed
(SEM) Seminars	1	Spanish	second semester	morning-mixed
(PLAB) Practical laboratories	2	Spanish	second semester	morning-mixed