UAB
Universitat Autònoma de Barcelona

Numerical Calculus

Code: 104390
ECTS Credits: 6

2024/2025

Degree	Type	Year
2503740 Computational Mathematics and Data Analytics	FB	1

Contact

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Teachers

Susana Serna Salichs

Teaching groups languages

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

Prerequisites

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

Objectives and Contextualisation

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

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

Content

Error propagation

Numerical solution of non-linear equations

Numerical linear algebra

Interpolation, differentiation, integration

Activities and Methodology

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

In the theoretical sessions, the lecturer will explain the different methods and their analysis. The explanation of the different methods will be accompanied by computer examples of their behavior, both for a better understanding of the methods and in order to introduce their analysis.

The problem sessions will be devoted to the solution of both theoretical and computational problems. Some of the computational ones will require the use of a calculator, whereas other problems will require the use of a computer. In this last case, the problems will not be computationally intensive, so the algorithms needed for their solution will be of a fast implementation in an interpreted Octave-type language. Problems will be solved by either the lecturer or the group.

The computer sessions are designed as an introduction to scientific computing. In these sessions, students will work in more computationally intensive problems, by implementing their solution in a compiled language. In doing this, students will progressively develop their personal library of routines for 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

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Computer work	0.25	0	0	CM05, SM05, SM06
Final exam	0.45	3	0.12	KM02, KM03, SM04, SM05, SM06
Partial exam	0.3	2	0.08	KM02, KM03, SM04, SM05, SM06

The course will be evaluated from three activities:

- Partial exam (PE): an exam of a part of the course, with theoretical questions and problems.
- Final exam (FE): an exam of the whole course, with theoretical questions and problems.
- Practical computer work (PR): delivery of code and a report.

Students will be given the option of taking an additional recovery exam (RE), of the same format of the FE exam. The practical work (PR) will not be recoverable.

In order to suceed, it is mandatory that max(0.4*PE+0.6*FE,FE,RE)>=4 and PR>=5.

The final grade of the course will be

0.75*max(0.4*PE+0.6*FE,FE,RE)+0.25*PR

Honor grades will be granted at the first complete evaluation. They will not be withdrawn even if another student obtains a larger grade after consideration of the RE exam.

The unique evaluationwill consist of a single ad-hoc exam on the day of the final exam that will weigh 100% of the theory grade.

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

Language list

Name	Group	Language	Semester	Turn
(PLAB) Practical laboratories	1	Spanish	second semester	morning-mixed
(SEM) Seminars	1	Spanish	second semester	morning-mixed
(TE) Theory	1	Spanish	second semester	morning-mixed