Universitat Autònoma de Barcelona

2020/2021

Numerical methods

Code: 100097
ECTS Credits: 12

Degree	Type	Year	Semester
2500149 Mathematics	OB	2	2

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Susana Serna Salichs

Prerequisites

As previous knowledge the students must know the basic results on continuity, derivability and integrability of real functions in one and several variables, on linear algebra and matrix calculation, and basic notions about algorithms and programming language C. These knowledges are the contents of linear algebra, real variable functions, computer tools for mathematics of the first year of the studies in mathematics, and the calculus in several variables, from the first semester of the second year.

Objectives and Contextualisation

Science and technology are supported by mathematical models of real phenomena, developed for predictive purposes. A minimum of realism gives rise to difficult resolvable models in a totally analytical way. One of the ways to study them is by calculating approximate solutions. The study of techniques (numerical methods) to obtain these approaches is the goal of the numerical analysis, this subject is an introduction. Numerical methods require a calculation effort depending on the complexity of the model and the desired precision. In accordance with the standards of today, this calculation effort forces the use of computers.

The subject's objective is double. On the one hand it has purely mathematical aspects that it shares with the other subjects of the degree. In addition, he wants to prepare the students to solve the numerical problems that they can find in their professional practice. This implies both the precise knowledge of several methods and their suitability in various situations as the dexterity in their application to the resolution of specific problems with the help of a computer.

Competences

- Actively demonstrate high concern for quality when defending or presenting the conclusions of ones work.
- Apply critical spirit and thoroughness to validate or reject both ones own arguments and those of others.

- Calculate and reproduce certain mathematical routines and processes with agility.
- Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
- Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
- Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
- Use computer applications for statistical analysis, numeric and symbolic calculus, graphic display, optimisation or other purposes to experiment with Mathematics and solve problems.
- When faced with real situations of a medium level of complexity, request and analyse relevant data and information, propose and validate models using the adequate mathematical tools in order to draw final conclusions

Learning Outcomes

1. Actively demonstrate high concern for quality when defending or presenting the conclusions of ones work.
2. Analyse the convenience of one or other numeric method for a specific problem.
3. Apply critical spirit and thoroughness to validate or reject both ones own arguments and those of others.
4. Evaluate the results obtained and draw conclusions after a computation process.
5. Implement algorithms in a structured programming language.
6. Students must be capable of applying their knowledge to their work or vocation in a professional way and they should have building arguments and problem resolution skills within their area of study.
7. Students must be capable of collecting and interpreting relevant data (usually within their area of study) in order to make statements that reflect social, scientific or ethical relevant issues.
8. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
9. Use algorithms for numerical resolution, program numerical methods on a computer and apply them effectively.
10. Use mathematical formalism in the design and verification of computer programmes.

Content

1.- Errors: Representation of real numbers. Arithmetic of floating point and formula of error propagation. Stable and unstable algorithms. Well and badly conditioned problems.
2.- Zeros of functions: Methods of bisection, Newton and secant. Fixed point methods. Order of convergence and efficiency. Methods of Newton and Chebyshev. Acceleration of convergence. Localization of roots for polynomials: Rule of Descartes, Sturm method, complex roots.
3.- Polynomial interpolation: Existence and uniqueness of the interpolation polynomial. Lagrange polynomials, Neville algorithm, Newton's divided differences. Generalized Hermite Interpolation. Error formulas. Interpolation by splines.
4.- Differentiation and numerical integration: Numerical derivation. Extrapolation of Richardson. Interpolation integration formulas, Newton-Cotes closed formulas, composite rules. Romberg method.
5.- Linear systems:Triangular systems Gauss method. Pivoting strategies. Factorization. Calculation of determinants and inverse of matrices. Bad conditioned systems. Classic iterative methods. Power method.

Methodology

The problem classes will consist in solving problems on the board with active participation of students.

Several practices will be proposed during the course. Each practice will contain a script, according to which a report must be submitted, which will be the basis for the score of the practice, together with the code developed in C. The delivery period will be announced for each practice. The practical sessions will take place in a computer room of the faculty, and will be devoted to the resolution of doubts related to the realization of

each practice. It is not expected that the students finish the practices during the practical sessions, but they will have to devote time to personal study.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Exercise classes	30	1.2	
Theoretical classes	45	1.8	
Type: Supervised			
Practical classes with computer	28	1.12	
Type: Autonomous			
Personal work	187	7.48	

Assessment

There will be four qualifications to evaluate the course:

First partial exam (EP1). Problems similar to those worked during problem classes and some theoretical questions must be solved.
Second partial (EP2). Problems similar to those worked during problem classes and some theoretical questions must be solved.
Practices note (Prac). The practices will have to be delivered throughout the course, with deadlines that will be announced in a timely manner. It is an indispensable requirement to pass the subject that the qualification of practices is equal to or greater than 3.5 out of 10.
Recovery test. The two partial examinations will be recovered together with a single exam.

The final grade in June (QFJ) will be obtained using the formula,

QFJ: = (35EP1 + 35EP2 + 30Prac) / 100

Students who obtain Prac> = 3.5, EP1>=3.5, EP2>=3.5 and QFJ> = 5 will have passed the subject.

For students who do not pass by course qualification, there will be a recovery test in July on all the subject matter of the course. Starting with your qualification, about 10, let's say EF, recalculate the course qualification changing 35EP1 + 35EP2 for 70EF. To pass it is also nedded to have EF>=3.5.

The criterion for obtaining the "no avaluable" qualification is: all students that deliver 2 practices or submit to one of the partial exams (EP1) or (EP2) will be considered presented.

MH will be awarded once the EP1 and EP2 examinations have been evaluated.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Delivery of practices	0.3	0	0	2, 3, 4, 5, 7, 9, 10

First test	0.35	3	0.12	2, 3, 1, 8, 6
Recovery exam	0.7	4	0.16	3, 8, 6
Second Test	0.35	3	0.12	2, 3, 1, 8, 6

Bibliography

Basic bibliography:

- J.M. Mondelo: Apunts de Mètodes Numèrics, Curs 2008-09. Accessibles a traves del Campus Virtual.
- A. Aubanell, A. Benseny, A. Delshams: Eines bàsiques de càlcul numèric, Manuals de la UAB 7, Publ. UAB, 1991.
- R. Burden, J.D. Faires: Numerical analysis, 6a ed., Brooks/Cole, 1997. En castellà: Análisis numérico, 6a ed., International Thomson, 1998.

Other bibliography:

- M. Grau, M. Noguera: Càlcul numèric, Edicions UPC, 1993.
- D. Kincaid, W. Cheney: Numerical analysis, 2a ed., Brooks/Cole, 1996. En castellà: An´alisis numérico, Addison-Wesley Iberoamericana, 1994.
- P. Henrici: Elements of numerical analysis, Wiley, 1964. En castellà: Elementos de anàlisis numérico, Trillas, 1968.
- G. Dahlquist, A Björk: Numerical methods, Prentice Hall, 1964.
- E. Isaacson, H.B. Keller: Analysis of numerical methods, Wiley, 1966.
- J. Stoer, R. Bulirsch: Introduction to numerical analysis, 2a ed., Springer, 1993.

Programming:

- B. Kernighan and D.M. Ritchie: The C programming language, 2a ed., Prentice-Hall 1998. En castellà: El lenguaje de programación C, Prentice-Hall Hispanoamericana, 1991.
- B.W. Kernighan, R. Pike: The practice of programming, Addison-Wesley 1999. En castellà: La pràctica de la programación, Pearson Educación, 2000.