2020/2021

Numerical integration of partial differential equations

Code: 100121
ECTS Credits: 6

Degree	Type	Year	Semester
2500149 Mathematics	OT	4	0

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

Joan Carles Artés Ferragud

Prerequisites

This course has no theoretical prerequisites, although having studied partial differential equations and / or numerical analysis will help to give context. For the practical part, there is a need of slight familiarity with the use of programming language C for scientific computing.

Objectives and Contextualisation

Partial differential equations (PDEs) are present in most mathematical models of physical processes. As with ordinary differential equations, closed formulas are available for their solution in very few cases. That is why, in almost all applications, numerical methods are required to approximate the solutions.

This course is an introduction to the numerical methods for the approximation of the solution of PDEs. It will focus on the development and analysis of finite difference methods and finite elements for "classical" equations (transport, waves, heat and potential)

Competences

- Actively demonstrate high concern for quality when defending or presenting the conclusions of ones work.
- Calculate and reproduce certain mathematical routines and processes with agility.
- Develop critical thinking and reasoning and know how to communicate it effectively, both in ones own languages and in a third language.
- Formulate hypotheses and devise strategies to confirm or reject them.
- Generate innovative and competitive proposals for research and professional activities.
- 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 communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
- Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
- 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.

Learning Outcomes

1. Actively demonstrate high concern for quality when defending or presenting the conclusions of ones work.
2. Develop critical thinking and reasoning and know how to communicate it effectively, both in ones own languages and in a third language.
3. Devise demonstrations of mathematical results of numeric calculus and numeric integration of PDEs.
4. Generate innovative and competitive proposals for research and professional activities.
5. Know how to numerically integrate ordinary differential equations and partial derivative equations.
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 communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
8. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
9. 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.

Content

1- Hyperbolic evolution problems. Finite differences schemes for the transport equation and conservation laws. The concepts of consistency, stability and convergence. The condition of Courant-Friedrichs-Lewy.

2-Parabolic evolution problems. Explicit and implicit finite differences schemes. Stability. The scheme of Crank-Nicolson.

3-Elliptical problems. Poisson problem. Stationary problems. Variational formulation. The method of Galerkin. Finite element method. Triangulations.

Methodology

The classes of theory and problems will be carried out in a normal classroom of the faculty. In them the presentation of theoretical aspects of the numerical methods and their basic properties with the resolution of problems of a theoretical nature will be undertaken. Students will work on lists of problems that will be provided throughout the course.

The practical classes will be carried out in a computer classroom of the faculty. During these sessions, students will solve some applied type problem through the implementation in a programming language of some of the methods studied in the subject. These practical sessions will be evaluated from the delivery at the end of the course (the date will be announced) of the code and a practical report.

Activities

Title	Hours	ECTS	Learning Outcomes

Type: Directed			
Exercise classes	10	0.4	1, 2, 3, 8, 6, 5
Practical classes	14	0.56	1, 2, 3, 8, 6, 5
Theory classes	26	1.04	1, 2, 3, 8, 5
Type: Autonomous			
Problems solving and practices	44	1.76	1, 2, 3, 8, 6, 5
Study	50	2	1, 2, 3, 8, 5

Assessment

The following evaluation activities will be carried out:

Partial exam (EP). Exam with theoretical questions and problems similar to those worked during the course.
Final Exam (EF). Examination of the whole subject with theoretical questions and problems similar to those worked during the course. It is a requirement to pass the subject that the grade of the final exam is equal to or greater than 3.5.
Note of Practices (Prac). It will be evaluated based on the project (program) and the practice report. It is a requirement to pass the subject that the qualification of the practices is equal to or greater than 3,5.

The final grade will be obtained using the formula

QF = Max{25EP+40EF+35Prac, 50EF+50Prac}/100

Additionally, students will be able (and will be recommended) to deliver some problems of the list of problems that will consist of experimenting with computer on the properties of some of the numerical methods that will be seen during the course. Evaluation of these problems may add a point (out of 10) to the EF rating.

There will be a resitting exam with the same format as the EF exam. The practices are not recoverable.

The "matrícula de honor" will be awarded after the first evaluation such that the subject can be passed.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final exam	0.4	3	0.12	1, 2, 3, 9, 6, 5
Partial exam	0.25	3	0.12	1, 2, 3, 6, 5
Practice delivery	0.35	0	0	1, 2, 4, 8, 7, 6, 5

Bibliography

Bibliography

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- M. G. Larson, F. Benzgon: The finite element method: Theory, implementation and applications. Springer, 2013.
- Josep Masdemont: Curs d'elements finits amb aplicacions. Edicions UPC, 2002.
- D. R. Lynch: Numerical Partial Differential Equations for Environmental Scientists and Engineers, Springer, 2005

Aditional bibliography

- P. G. Ciarlet: The Finite element methods for elliptic problems. North Holland, 1979.
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- Leveque,R.J.: Finite difference Methods for Ordinary and Partial Differential Equations, SIAM, 2007.
- P.A. Raviart, J.M. Thomas: Introduction à l'analyse numérique des équations aux dérivées partielles, Masson, 1983.