Universitat Autònoma de Barcelona

Ordinary Differential Equations

2020/2021

Code: 104397
ECTS Credits: 6

Degree	Type	Year	Semester
2503740 Computational Mathematics and Data Analytics	OB	2	1

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

It is very convenient for the student to have achieved a good knowledge of the contents in Calculus in one variable, Linear algebra and Numerical analysis of the first course, as well as the numerical methods of the subject "Numerical and Probabilistic Methods" of the first semester of the second year.

Objectives and Contextualisation

The objective of the subject is to present differential equations as a quantitative deterministic modeling tool for many processes of physics, chemistry, biology, etc. Also, the study of the solutions of these differential equations when they can be obtained in a closed form, when qualitative analysis is convenient and when approximate numerical computation turns out to be indispensable.

Competences

- Apply basic knowledge on the structure, use and programming of computers, operating systems and computer programs to solve problems in different areas.
- Calculate and reproduce certain mathematical routines and processes with ease.
- Design, develop and evaluate efficient algorithmic solutions to computational problems in accordance with the established requirements.
- Formulate hypotheses and think up strategies to confirm or refute them.
- Make effective use of bibliographical resources and electronic resources to obtain information.
- Relate new mathematical objects with other known objects and deduce their properties.
- 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 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, numerical and symbolic computation, graphic visualisation, optimisation and other to experiment and solve problems.
- Using criteria of quality, critically evaluate the work carried out.

Learning Outcomes

1. Contrast, if possible, the use of calculation with the use of abstraction in solving a problem.
2. Describe the concepts and mathematical objects pertaining to the subject.
3. Develop autonomous strategies for solving problems such as identifying the ambit of problems within the course, discriminate routine from non-routine problems, design an a priori strategy to solve a problem, evaluate this strategy.
4. Evaluate and analyse the complexity of computational algorithmic solutions in order to develop and implement that which guarantees best performance.
5. Evaluate the advantages and disadvantages of using calculation and abstraction.
6. Handle specific scientific software for the application of numerical algorithms or the automatic realisation of symbolic calculations aimed at solving particular problems.
7. Identify the essential ideas in the demonstration of ceratin basic theorems and know how to adapt these to obtain other results.
8. Make effective use of bibliographical resources and electronic resources to obtain information.
9. Numerically integrate ordinary differential equations and partial differential equations.
10. Programme mathematical-calculation algorithms.
11. Select and use algorithmic structures and the representation of appropriate data to solve a problem.
12. 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.
13. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
14. 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.
15. Understand the internal functioning of computers and be critical of the results that they provide.
16. Using criteria of quality, critically evaluate the work carried out.
17. Verify and ensure the correct operation of an algorithmic solution in accordance with the requirements of the problem to be resolved.

Content

Ordinary differential equations
1. Differential equations as a modeling tool. The initial value problem. Existence and uniqueness and dependence on initial conditions and parameters.
2. The scalar differential equations. Autonomous differential equations. Asymptotic behavior. Examples and applications: the balance of matter and population dynamics.
4. Systems of nonlinear differential equations. Lyapunov stability. Linearization. Phase plane. Applications to mechanics, ecology and chemical kinetics.
5. Numerical resolution methods. The Runge-Kutta methods.

Methodology

Two hours of theory class per week correspond to this subject. In addition, 11 hours of seminar will be held where students will solve exercises raised by the teacher, both with conventional tools and using a symbolic manipulator. There will also be 12 hours of practical classes that will be devoted mainly to the approximate calculation of solutions of differential equations. It is essential that students have at their disposal the software that teachers recommend during the course. The Virtual Campus of the subject will provide all the material and all the information related to this subject that is necessary for the student.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Theory classes	30	1.2	16, 5, 4, 1, 2, 7, 9, 10, 14, 13, 12, 8, 17
Type: Supervised			
Practical classes	12	0.48	16, 4, 15, 3, 7, 9, 6, 10, 12, 11, 8, 17
Seminars	11	0.44	5, 4, 1, 15, 3, 7, 9, 6, 10, 14, 13, 12, 11, 17
Type: Autonomous			
Personal study	64	2.56	16, 5, 4, 1, 15, 2, 3, 7, 9, 6, 10, 14, 12, 11, 8, 17
Program design and report writing	27	1.08	16, 5, 4, 1, 15, 3, 7, 9, 6, 10, 14, 13, 12, 11, 8, 17

Assessment

The assessment of the course will be carried out mainly from three activities:
Partial exam (EP): exam of part of the subject, with theoretical questions and problems. Final exam (EF): exam of the whole subject, with theoretical questions and problems. Computer Practices (PR): code and report deliveries.

Additionally, one more point in the evaluation of one of the seminars (SEM) that will be carried out will be possible.

In addition, students will be able to submit to a ressiting exam (ER) with the same characteristics as the exam (EF). Practices will not be recoverable.

It is a requirement to pass the subject that max (0.35 * EP + 0.65 * EF, EF, ER)> = 3.5 and that PR> = 3.5.

The final grade of the subject will be
0.7 * max (0.35 * EP + 0.65 * EF, EF, ER) + 0.3 * PR + 0.1 * SEM (if this mark does not exceed 10).

The "matrícula de honor" will be awarded to the first complete evaluation of the subject. Later achievements will not be considered for this purpose.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final exam	35%	3	0.12	16, 5, 1, 15, 2, 3, 7, 14, 13, 12, 11
Partial exam	25%	3	0.12	16, 5, 1, 2, 3, 7, 14, 13, 12, 11
Practices	30%	0	0	16, 5, 4, 1, 15, 3, 9, 6, 10, 13, 11, 8, 17
Seminars evaluation	20%	0	0	16, 5, 4, 1, 15, 2, 3, 7, 9, 6, 14, 13, 12, 11, 8, 17

Bibliography

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J. Stoer and R. Burlisch, *Introduction to numerical analysis*, 3a ed, Springer, 2002

Dennis G. Zill Ecuaciones diferenciales con aplicacions de modelado. Thompson, 1997