UAB
Universitat Autònoma de Barcelona

Differential Equations and Modelling I

Code: 100100
ECTS Credits: 9

2025/2026

Degree	Type	Year
Mathematics	OB	3

Contact

Name: David Rojas Perez

Email: david.rojas@uab.cat

Teachers

Joan Carles Artés Ferragud

Joan Torregrosa Arus

Teaching groups languages

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

Prerequisites

Linear Algebra

Fundaments of mathematics

Calculus in 1 and several real variables.

Objectives and Contextualisation

The Theory of Differential Equations is distinguished both by the richness of ideas and methods as well as by its applicability. Thus the subject Differential Equations and Modeling I has a theoretical aspect (that will be used in theory and problem lessons) as well as a very applied aspect (which will be introduced in the theory sessions and will be developed in problems and practical sessions). Practical lessons will be carried out in the computer lab. On the one hand we will emphasize the presentation of the theory and the demonstration of the results and on the other hand the students will learn how to model real situations that allow them to predict the studied behaviors.

We believe that this subject is good to show to the students that certain theoretical results that they already know about other subjects (topological properties of normed spaces and Jordan canonical forms, for example) can be applied to develop the theory of differential equations.

Competences

- Actively demonstrate high concern for quality when defending or presenting the conclusions of one's work.
- Identify the essential ideas of the demonstrations of certain basic theorems and know how to adapt them to obtain other results.
- Recognise the presence of Mathematics in other disciplines.
- 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.
- Use computer applications for statistical analysis, numeric and symbolic calculus, graphic display, optimisation or other purposes to experiment with Mathematics and solve problems.
- Work in teams.

Learning Outcomes

1. Actively demonstrate high concern for quality when defending or presenting the conclusions of one's work.
2. Apply the main methods for resolving ordinary differential equations and some simple partial derivative equations.
3. Resolve linear systems of ordinary differential equations.
4. 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.
5. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
6. Translate some real problems into the terms of ordinary differential equations and partial derivative equations.
7. Work in teams

Content

1. First-Order Differential Equations in One Variable

1.1 Introduction to Differential Equations. Solution methods: separable equations, linear equations, exact equations, integrating factors. Change of variable.

1.2 Applications: Radioactive decay, mixture problems, population models, etc.

2. The Fundamental Theorems

2.1 The space of continuous and bounded functions over a topological space: Existence and uniqueness of solutions, maximal interval of solutions, structure of the solution space, fundamental matrices.

2.2 Picard and Peano Theorems: Locally Lipschitz functions. Local existence and uniqueness. Stone-Weierstrass and Peano's proof.

2.3 Extension of solutions: Existence and uniqueness of non-extendable solutions for problems with existence and uniqueness. Wintner's Lemma.

2.4 Continuous and differentiable dependence of solutions on initial conditions and parameters: Statement of theorems and examples.

3. Linear Equations

3.1 General properties of linear differential equations: Existence and uniqueness of solutions for the Cauchy problem, structure of the solution space for linear equations, fundamental matrices.

3.2 Systems of linear equations with constant coefficients: Matrix exponential. Computation of the exponential of Jordan canonical matrices. The nonhomogeneous case.

3.3 The linear equation of order n: General properties. Homogeneous equations with constant coefficients. Computation of particular solutions for the nonhomogeneous case.

3.4 The second-order linear equation: Mechanical systems, electrical circuits, forced periodic oscillations. The phenomenon of resonance.

4. Qualitative Theory of Autonomous Systems

4.1 Dynamical system induced by an autonomous differential equation. Critical points and periodic orbits. Stability. Equivalence and conjugacy.

4.2 Tubular flow theorem. Hartman's theorem.

4.3 Qualitative study of linear equations.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practical modelization problems	24	0.96	
Theory classes	30	1.2	
Type: Supervised			
Problem classes	29	1.16	
Type: Autonomous			
Study of the theory and resolution of problems	115	4.6	

Fundamental in the learning process of the subject is the work by the student, who can count on the guidance of the teacher at each moment.

There will be three types of guided activities:

Theory Classes: The teacher introduces the basic concepts of the subject matter showing examples, demostrating properties and fundamental results. The student must complement the teacher's explanations with personal study.

Classes of Problems: We work on the understanding and application of the concepts and tools introduced to theory, with the realization of theoretical and/or practical exercises. It is well known that the only way to learn mathematics is by solving lots and lots of problems. For this reason the student must dedicate a minimum of 5 hours a week to solving problems in this subject. The student will have a list of problems for each theme, which he must think about, try to solve and which will be worked on in the problem classes. A delivery of problems is requested for each theme to ensure that this work is done continuously.

Computer practices: in each session a different type of differential equation will be dealt with to model a real situation and predict future behaviors depending on circumstancial parameters.

The exercises that appear in the lists of Problems or Computer Practices and that have not finished in the corresponding session the student will have to solve them like part of his autonomous work.

The notes on the Theory, the lists of Problems and Computer Practices will be posted on the subject's Moodle Aules website; a summary of the Theory and Problem classes will be posted weekly.

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
First partial exam	35%	4	0.16	2, 1, 4, 3, 6
Handout of practical work	20%	15	0.6	5, 4, 3, 6, 7
Retake exam	80%	4	0.16	2, 1, 4, 3, 6
Second partial exam	45%	4	0.16	2, 1, 4, 3, 6

The single assessment will consist of a single examination of the entire subject on the day of the second partial examination, which will weigh 100% of the grade.
Continuous evaluation: It will consist of the following evaluation activities

- Practice deliveries. This activity is NOT recoverable.
- A partial exam in the middle of the semester.
- A partial exam at the end of the semester. This exam will cover all the material that has not been evaluated in the first part.

Make-up exam: it will consist of an exam of the entire subject that replaces the two partial exams.
NOTE: None of the two partial exams release material for the make-up exam. As stated before, the resit exam weighs 80% of the grade.

Bibliography

P. Blanchard, and R.L. Devaney. *Differential Equations*. G.R. Hall, 2002. Traduït al castellà: "Ecuaciones Diferenciales". International Thomson Editores, México, 1999.

E. Boyce, y R.C. Di Prima. *Ecuaciones Diferenciales y Problemas con Valores en la Frontera*. Ed. Limusa, México, 1967.

R. Cubarsí. *Equacions diferencials i la transformada de Laplace.* Iniciativa Digital Politècnica, 2012. (http://hdl.handle.net/2099.3/36610)

C. Fernandez y J.M. Vegas. *Ecuaciones diferenciales*. Pirámide, Madrid, 1996.

G. Fulford, P. Forrester, A. Jones. *Modelling with differential and difference equations*. Cambridge University Press, New York, 1997.

M. Guzmán. *Ecuaciones diferenciales ordinarias*. Ed. Alhambra, Madrid, 1978.

V. Jimenez. *Ecuaciones diferenciales*. Serie: enseñanza. Universidad de Murcia, 2000.

M.C. Leseduarte, M. D. Llongueras, A. Magaña, R. Quintanilla de Latorre. *Equacions Diferencials: Problemes resolts.* Iniciativa Digital Politècnica, 2012. (http://hdl.handle.net/2099.3/36607)

F. Mañosas. *Apunts d'Equacions diferencials.* Campus virtual.

R. Martínez. *Models amb Equacions Diferencials*. Materials de la UAB, Servei de Publicacions de la UAB, no. 149. Bellaterra, 2004.

G.A. Muñozy J.B. Seoane. *Fundamentos y problemas resueltos de Teoria cualitativa de ecuaciones diferenciales.* Paraninfo, Madrid, 2017.

H. Ricardo. *Ecuaciones diferenciales: una introducción moderna*. Editorial Reverté, Barcelona, 2008.

J. Sotomayor. *Equações diferenciais ordinárias.* Textos Universitários do IME-USP, Editora Livraria da Física, 2011.

D.G. Zill. *Ecuaciones diferenciales con aplicaciones de modelado*. International Thomson Editores,México, 2001.

Software

Anything related to differential equations.

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan	first semester	morning-mixed
(PAUL) Classroom practices	2	Catalan	first semester	morning-mixed
(PLAB) Practical laboratories	1	Catalan	first semester	morning-mixed
(PLAB) Practical laboratories	2	Catalan	first semester	morning-mixed
(TE) Theory	1	Catalan	first semester	morning-mixed