2022/2023

Differential equations and modelling I

Code: 100100
ECTS Credits: 9

Degree	Type	Year	Semester
2500149 Mathematics	OB	3	1

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

Juan Miguel Garrido Peláez

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. Differential Equations of the first order.

1.1 Introduction to differentia equations. Separable equatiuons. Exact equations.

1.2 Applications to modelling.

2. The linear equation.

2.1 Uniqueness and existence theorems. Algebraic properties of the space of solutions. Liouville's theorem.

2.2 The autonomous case: Exponencial of a matrix.

2.3 The linear equation of order n.

3. Uniqueness and existence theorems

3.1 The Cauchy's problem. Picard and Peano theorems.

3.2 Prolongation of solutions. Wintner's lemma

3.3 Continuous and differentiable dependence on initial data and parameters.

4. Qualitative theory of autonomous systems.

4.1 Dynamical systems.Critical points and periodic orbits. Stability. Conjugation of dynamical systems.

4.2 Tubular flow theorem. Hartman's theorem.

4.3 Qualitative study of the autonomous linear equation.

Methodology

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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practical modelization problems	12	0.48	
Theory classes	30	1.2	
Type: Supervised			
Problem classes	30	1.2	
Type: Autonomous			
Study of the theory and resolution of problems	114	4.56	

Assessment

Continuous evaluation:

- handouts of computer sessions (30%). Denote its total score by Prt/10
- 2 handouts of Problems (10%). Denote their scores by E1/10 and E2/10 respectively.
- 2 partial exams, each counting for 30% in the overall note. Denote their scores by EP1/10 and EP2/10 respectively.

Evaluation that can be repeated to get a new oportunity:

- In case one takes the opportunity to improve the actual score, this new opportunity counts for 50%, replacing part of the note obtained for the partial exams. This new oportunity exam is about all course material.

It is necessary to have obtained an average note of at least 3.5/10 for the partial exams (respectively new oportunity) in order that the other notes of avaluation will be taken into account.

The final score before taking a second oportunity, denoted by EF1, is determined by the handouts of problems (E1 and E2), both partial exams (EP1 and EP2) and the practical sessions (Prt) in the following way:

- If EP1+EP2<7, the final score is EF1 = (EP1+EP2)/2
- Else the final score is EF1 = 0.05 * (E1 + E2) + 0.3 * (EP1+EP2) + 0.3 * Prt

In each case, when going for a second opportunity, obtaining the score ER/10 for this exam, then the final and definite score EF2 will be:

- If ER>=3.5, then NF2 = 0.05*(E1 + E2 + EP1 + EP2) + 0.3*Prt + 0.5 ER
- If ER<3.5: NF2 = ER

Everyone can go for a second oportunity, however

- honors are only atributed based on the score EF1;
- the score EF1 will be replaced by EF2.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Handout of practical work	30%	15	0.6	5, 4, 3, 6, 7
Handout of problemes	10%	12	0.48	2, 1, 4, 3, 6, 7
Partial exams	60%	8	0.32	2, 1, 4, 3, 6
Repeated final exam	50%	4	0.16	2, 1, 4, 3, 6

Bibliography

F. Mañosas. *Apunts d'Equacions diferencials.* Aula Moodle.

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

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.L. Borrelli and C.S. Coleman. *Differential equations: a modeling perspective*. Prentice-Hall, 1987.

M. Braun. *Ecuaciones diferenciales y sus aplicaciones*. Grupo Editorial Iberoamérica. México, 2000.

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.

M. W. Hirsch , S. Smale, R. Devaney. *Differential Equations, Dynamical Systems: An Introduction to Chaos.* Elsevier, 2003.

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)

R.K. Nagle, E.B. Saff and A.D. Snyder. *Fundamentos de Ecuaciones diferenciales*. Addison Wesley, 1992.

G.F. Simmons. *Ecuaciones diferenciales con aplicaciones y notas históricas*. Mc Graw-Hill, 1977.

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

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

Software

In the computer sessions the students makes use of the programs SAGE and Excel; to resolve the problems proposed in these sessions students often receive information in the language of the computer algebra package of Mathematica.

There will also made use of the program P4 to show the behavior in the neighbourhood of critical points for polinomial systems in two dimensions.