COURSE DATA

DATA SUBJECT

Code: 36588
Name: Ordinary Differential Equations P-M
Cycle: Undergraduate Studies
ECTS Credits: 9
Academic year: 2025-26

STUDY (S)

Degree	Center	Acad. year	Period
1928 - Double Degree Program Physics-Mathematics	Facultat de Ciències Matemàtiques	2	Annual

SUBJECT-MATTER

Degree	Subject-matter	Character
1928 - Double Degree Program Physics-Mathematics	Segundo Curso (Obligatorio)	COMPULSORY

COORDINATION

MULET MESTRE PEP

SANTOS PEREZ SAMUEL

SUMMARY

Examples of the application of ordinary differential equations (ODEs) to the natural sciences, especially physics, will be introduced. Basic concepts of ODEs will also be presented, starting from the Cauchy problem. Formal methods for finding solutions will be studied; in particular, the solving of linear differential equations and systems, as well as solving ODEs using power series and special functions.

Methods for obtaining information about unsolved solutions and stability issues will be addressed.

An introduction to basic numerical methods for the numerical approximation of ODE solutions will be provided.

PREVIOUS KNOWLEDGE

RELATIONSHIP TO OTHER SUBJECTS OF THE SAME DEGREE

There are no specified enrollment restrictions with other subjects of the curriculum.

OTHER REQUIREMENTS

The following previous knowledge is required:

1. Differential calculus in one and several variables.
2. Integration in one variable and multiple integrals.
3. Real sequences and numerical series.
4. Power series.
5. Linear systems.
6. Vector spaces.
7. Matrices and determinants, linear operators, eigenvalues, and eigenvectors.
8. Jordan canonical form.
9. Programming in MATLAB.

It is also advisable to know how to use spreadsheet software.

COMPETENCES / LEARNING OUTCOMES

DESCRIPTION OF CONTENTS

1. Introduction

- Examples of ODEs and models.
- Examples of solutions.
- Vector field.
- First integrals.

2. Explicit solution of scalar ODEs

- First-order linear ODE: existence and uniqueness of solutions for the initial value problem (IVP).

- Separable ODEs: existence and uniqueness of solutions for the IVP.

- Exact, Bernoulli, Riccati, homogeneous ODEs.

- Second-order linear ODEs with constant coefficients: existence and uniqueness of IVP solutions; Wronskian; characteristic equation.

- nth-order linear ODEs with constant coefficients: existence and uniqueness of IVP solutions; solution dimension; Wronskian; characteristic equation.

3. First-order linear systems with constant coefficients

- Relation with nth-order scalar ODE.

- Solution by diagonalization.

- Variation of parameters.

4. Power series solution: ordinary points

- Power series solution of second-order linear equations with analytic coefficients. Ordinary points.

5. Power series solution: regular singular points

- Frobenius method for solutions around a regular singular point.

6. Analysis of the general IVP

- Equivalence of scalar IVP with scalar integral equation.

- Existence and uniqueness of the scalar IVP solution.

- Extendability of the scalar IVP solution.

- Existence and uniqueness of the general IVP solution.

7. Numerical methods

- Euler, Heun, Runge-Kutta methods.
- Order and convergence.

8. Qualitative theory of dynamical systems

- Dynamical systems.
- Equilibrium points, orbits, phase space.
- Stability.

9. Special functions

- Solutions of Legendre, associated Legendre, Hermite, and Laguerre differential equations.
- Rodrigues' formula, recurrence relations, and orthogonality for Legendre, Hermite, and Laguerre polynomials.
- Bessel functions.
- Hypergeometric function.

WORKLOAD

PRESENCIAL ACTIVITIES

Activity	Hours
Theory	45,00
Other activities	11,00
Computer classroom practice	15,00
Classroom practices	19,00
Total hours	**90,00**

NON PRESENCIAL ACTIVITIES

Activity	Hours
Attendance at other activities	0,00
Individual or group project	40,00
Independent study and work	20,00
Preparation of lessons	60,00
Preparation for assessment activities	15,00

Resolution of case studies	0,00
Total hours	**135,00**

TEACHING METHODOLOGY

The course is structured around three main components: theory sessions, practical classes, and tutorials and seminars.
Regarding the theory sessions, the instructor will cover the main topics of the syllabus. Students are expected to dedicate the necessary preparation time to these classes to ensure optimal learning. The practical classes will allow students to verify their level of understanding by tackling relatively complex problems and analyzing the results obtained. As with the theory sessions, students must prepare for these practical sessions to complete the theoretical/practical exercises within the allotted time.

EVALUATION

The assessment of students' knowledge and skills will be conducted continuously throughout the course and will consist of the following evaluation components:

1. Practical work (up to 2 points, i.e., 20% of the final grade): Submission of work completed during some sessions.

2. Theoretical-practical exams (up to 7 points, i.e., 70% of the final grade): Evaluation based on two midterms in the first exam period and final exams in both the first and second exam periods.

3. Seminars and tutorials (up to 1 point, i.e., 10% of the final grade).

To pass the course, it is necessary to achieve at least 40% of the maximum score in Component 2.

Grades obtained in Components 1 and 3 will be considered valid for both exam periods of the academic year in which they were obtained, as their evaluation is only possible during the course.

REFERENCES

- A.D. Polyanin, V. F. Zaitsev, Handbook of exact solutions for Ordinary Differential Equations, Chapman and Hall/CRC, 2003.

- R. Kent Nagle, E.B. Saff, Fundamentos de ecuaciones Diferenciales, Addison Wesley Iberoamericana.

- M. Braun, Differential equations and their applications, Springer, 1993.

- P. Hartman, Ordinary differential applications, SIAM, 2002.
- G. Teschl, Ordinary Differential Equations and Dynamical Systems, AMS, 2012
- K.F. Riley, M.P. Hobson, S. J. Bence, Mathematical Methods for Physics and Engineering, Cambridge University Press, 2006.