

Ordinary differential equations

Academic Year: (2023 / 2024)

Review date: 09-02-2024

Department assigned to the subject: Mathematics Department

Coordinating teacher: ALVAREZ CAUDEVILLA, PABLO

Type: Compulsory ECTS Credits : 6.0

Year : 3 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Linear Algebra (First course, first semester)
 Differential Calculus (First course, first semester)
 Integral Calculus (First course, second semester)
 Linear Geometry (First course, second semester)

SKILLS AND LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.

CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.

CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.

CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.

CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.

CG1. Students are able to demonstrate knowledge and understanding of concepts in mathematics, statistics and computation and to apply them to solve problems in science and engineering with an ability for analysis and synthesis.

CG2. Students are able to formulate in mathematical language problems that arise in science, engineering, economy and other social sciences.

CG4. Students are able to show that they can analyze and interpret, with help of computer science, the solutions obtained from problems associated to real world mathematical models, discriminating the most relevant behaviours for each application.

CG5. Students can synthesize conclusions obtained from analysis of mathematical models coming from real world applications and they can communicate in verbal and written form in English language, in a clear and convincing way and with a language that is accessible to the general public.

CG6. Students can search and use bibliographic resources, in physical or digital support, as they are needed to state and solve mathematically and computationally applied problems arising in new or unknown environments or with insufficient information.

CE1. Students have shown that they know and understand the mathematical language and abstract-rigorous reasoning as well as to apply them to state and prove precise results in several areas in mathematics.

CE4. Students have shown that they understand the fundamental results from the theory of ordinary differential equations as well as the theory of partial derivative and stochastic equations.

CE7. Students are able to construct mathematical models of both discrete and continuous processes that appear in real world applications emphasizing the use of deterministic and stochastic difference and differential equations.

RA1. Students must have acquired advanced cutting-edge knowledge and demonstrated indepth understanding of the theoretical and practical aspects of working methodology in the area of applied mathematics and computing.

RA2. Through sustained and well prepared argument and procedures, students will be able to apply their knowledge, their understanding and the capabilities to resolve problems in complex specialized professional and work areas requiring the use of creative and innovative ideas.

RA3. Students must have the capacity to gather and interpret data and information on which they base

their conclusions, including where relevant and necessary, reflections on matters of a social, scientific, and ethical nature in their field of study.

RA4. Students must be able to perform in complex situations that require developing novel solutions in the academic as well as in the professional realm, within their field of study.

RA5. Students must know how to communicate with all types of audiences (specialized or not) their knowledge, methodology, ideas, problems and solutions in the area of their field of study in a clear and precise way.

RA6. Students must be capable of identifying their own education and training needs in their field of study and the work or professional environment and organize their own learning with a high degree of autonomy in all types of contexts (structured or not).

RA7. Students must possess the professional maturity necessary to choose and evaluate their work objectives in a reflexive, creative, self-determined and responsible way, for the betterment of society.

OBJECTIVES

The student must acquire the knowledge to solve differential equations as well as the modelization of applied problems through differential equations.

A) Learning objectives

- Develop models of differential equations
- Model and solve first order differential equations
- Understand the concept of solution of a differential equation in all its forms
- To understand the theorems of existence and uniqueness of solutions
- Model and solve second order differential equations
- Understand the concept of solution space as well as its existence
- Modeling and solving systems of linear differential equations
- Stability of solutions for linear systems. Phase diagrams
- Phase diagrams for systems of nonlinear differential equations

B) Specific skills

- Be able to solve systems of linear equations
- Be able to model real life problems by means of differential equations and solve them by means of algorithmic procedures
- To be able to understand the abstract properties of differential equations

C) General skills

- Be able to think abstractly, and apply mathematical techniques to obtain information for differential equations.
- Be able to communicate orally and in writing using appropriate mathematical language
- Be able to model a real problem using differential equations
- Be able to interpret the solution of a mathematical problem, its accuracy and limitations
- Be able to use mathematical software

DESCRIPTION OF CONTENTS: PROGRAMME

1. Origins of ODEs in the applications
2. First order equations
3. Linear second order equations, higher order and linear differential systems
4. Existence, uniqueness and continuation of solutions
5. Resolution of ODEs with power series.
6. Nonlinear equations. Autonomous systems, phase plane, classification of critical points and stability theorems

LEARNING ACTIVITIES AND METHODOLOGY

THEORETICAL-PRACTICAL CLASSES. [44 hours with 100% classroom instruction, 1.67 ECTS]

Knowledge and concepts students must acquire. Student will take notes during the lessons and will have basic reference texts to facilitate following the classes and carrying out follow up work. Students will get involved in solving exercises and practical problems. Also they will develop projects related to the different topics and take evaluation tests, all geared towards acquiring the necessary capabilities.

TUTORING SESSIONS. [4 hours of tutoring with 100% on-site attendance, 0.15 ECTS]

Individualized attendance (individual tutoring) or in-group (group tutoring) for students with a teacher.

STUDENT INDIVIDUAL WORK OR GROUP WORK [98 hours with 0 % on-site, 3.72 ECTS]

WORKSHOPS AND LABORATORY SESSIONS [8 hours with 100% on site, 0.3 ECTS]

FINAL EXAM. [4 hours with 100% on site, 0.15 ECTS]

Global assessment of knowledge, skills and capacities acquired throughout the course.

METHODOLOGIES

THEORY CLASS. Classroom presentations by the teacher with IT and audiovisual support, if necessary, in which the subject's main concepts are developed, while providing material and bibliography to complement student learning.

PRACTICAL CLASS. Resolution of practical cases and problem, posed by the teacher, and carried out individually or in a group.

TUTORING SESSIONS. Individualized attendance (individual tutoring sessions) or in-group (group tutoring sessions) for students with a teacher as tutor.

LABORATORY PRACTICAL SESSIONS. Applied/experimental learning/teaching in workshops and laboratories under the tutor's supervision.

ASSESSMENT SYSTEM

SE1 - FINAL EXAM. [50 %]

Global assessment of knowledge, skills and capacities acquired throughout the course.

SE2 - CONTINUOUS EVALUATION. [50 %]

Assesses papers, projects, class presentations and workshops throughout the course.

% end-of-term-examination: 50

% of continuous assessment (assignments, laboratory, practicals...): 50

BASIC BIBLIOGRAPHY

- Earl A. Coddington An Introduction to Ordinary Differential Equations, Courier Corporation, 2012
- James C. Robinson An introduction to Ordinary Differential Equations, Cambridge University Press, 2004
- Steven G. Krantz Differential Equations. Theory, Technique and practice, CRC Press, 2015
- V. I. Arnold Ordinary Differential Equations, Springer, 1984

ADDITIONAL BIBLIOGRAPHY

- D. K. Arrowsmith, C. M. Place Ordinary Differential Equations, Chapman and Hall Mathematics Series, 1990
- George F. Carrier, Carl E. Pearson Ordinary Differential Equations, SIAM, 1968
- Herman Feshbach, Philip M. Morse Methods of Theoretical Physics, Mc Graw Hill, 1953
- J. Hale, H. Koçak Dynamics and Bifurcations, Springer-Verlag, 1991
- R. Kent Nagle, Edward B. Saff, Arthur David Snider Fundamentals of Differential Equations and Boundary Value Problems, Pearson, 2018
- Robert Mattheij, Jaap Molenaar Ordinary Differential Equations in Theory and Practice, SIAM, 2002