Universitat Autònoma de Barcelona

2021/2022

Differential Equations

Code: 100152
ECTS Credits: 8

Degree	Type	Year	Semester
2500097 Physics	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: No
Some groups entirely in Spanish: Yes

Teachers

José María Crespo Vicente
Carlo Marconi
Oscar Blanch Bigas

Prerequisites

It is advisable to have a good knowledge of calculus in one variable

Objectives and Contextualisation

Give tools to solve the most common types of ordinary differential equations and equations with partial derivatives that appear in Physics. Learn to model different physical phenomena.

Competences

- Develop the capacity for analysis and synthesis that allows the acquisition of knowledge and skills in different fields of physics, and apply to these fields the skills inherent within the degree of physics, contributing innovative and competitive proposals.
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project

Learning Outcomes

1. Applying Sturm-Liouvilles theory to physical problems with boundary conditions.
2. Identify situations in which a change or improvement is needed.
3. Solve Laplace and Poisson equations for simple geometries.
4. Solve the equations of simple harmonic, damped and forced motion.
5. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
6. Use the mathematical tools developed in this subject for the quantitative study of advanced problems in any branch of knowledge.
7. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.

Content

1. Introduction to ordinary differential equations (ODEs)
   (tentative) Numerical methods: Euler, Runge-Kutta.
3. First order ODEs
   1. Picard's method. Existence and uniqueness theorems
   2. Families of curves. Clairaut's equation. Envelops.
   3. Lineal ODEs, Bernoulli's equation, Ricatti's equation.
   4. Exact ODEs. Integrating factors.
4. Higher order linear ODEs
   1. Wronskian. Homogeneous ODEs with constant coefficients.
   2. Method of annihilators. Method of undetermined coefficients. Variation of parameters. Reduction of order.
   3. Cauchy-Euler's equation.
5. The Laplace transform (tentative)
6. Power series solutions of linear ODEs
   Ordinary points and regular singular points. Frobenius' method.
   Some important ODEs: Legendre, Bessel, Hermite, etc.
8. Introduction to Sturm-Liouville's theory
   Regular Sturm-Liouville eigenvalue problems.
   Orthonormal functions. Generalized Fourier series.
   Some examples of singular Sturm-Liouville problems.
10. Introduction to partial differential equations

Methodology

The subject is structured as follows:

- Theory lectures. The definitions, theorems, and methods of resolution of differential equations are presented, also solving some examples.
- Problem solving classes. Some of the problems of the lists that are made available to students at the beginning of the course through the Virtual Campus are resolved
- Supervised problem solving classes. Students try to solve problems in the classroom under the supervision of a teacher
- Homework assigments. Problems of more complexity and extension that are periodically posted throughout the course. The students must solve and submit before their correction in class in previously agreed dates. The objective is to encourage self-learning.

The course will be taught mainly in Catalan and Spanish but there may be sections of the notes and problems in

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			
Problem solving classes	22	0.88	1, 5, 3, 4, 7, 6
Theory lectures	44	1.76	1, 5, 3, 4, 7, 6
Type: Autonomous			
Homework assigments	18.5	0.74	1, 5, 3, 4, 7, 6
Problem solving	60	2.4	1, 5, 3, 4, 7, 6
Study of the theoretical concepts and methods	47	1.88	1, 5, 3, 4, 7, 6

Assessment

- Midterm exam (40%-50%)
- Final exam (40%-50%)
- Homework assignements (0%-20%)
- Students with a resultant grade below 5, or students wishing to improve their grades, can take a reassessment exam. They have to have taken both partial exams to qualify for reassessment.
- Resit exam (100%)

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final Exam	40% - 50%	2.5	0.1	1, 2, 5, 3, 7, 6
Homework assignements	0% - 20%	0	0	1, 2, 5, 3, 4, 7, 6
Midterm exam	40% - 50%	2.5	0.1	2, 5, 4, 7, 6
Resit Exam	100%	3.5	0.14	1, 2, 5, 3, 4, 7, 6

Bibliography

- Notes on the subject, which will be available to students through *Campus Virtual*
- Problems on the subject, which will be available to students through *Campus Virtual*
- Notes on the subject by Dr. Marià Baig which are made available to students through *Virtual Campus*
- *Elementary Differential Equations and Boundary Value Problems,* W.E. Boyce & R.C. DiPrima, John Wiley and Sons Ltd (2012)
- *Teoría y Problemas de Ecuaciones Diferenciales Modernas*, Schaum, McGraw-Hill
- *Ecuaciones Diferenciales y sus Aplicaciones*, M. Braun, Grupo Editorial Iberoamericana

Software

It is recommended to use Python to make plots and for numerical methods (tentative).