Universitat Autònoma de Barcelona

**2021/2022**

# Differential Equations and Vector Calculus

Code: 102425
ECTS Credits: 6

| Degree | Type | Year | Semester |
|---|---|---|---|
| 2500897 Chemical Engineering | FB | 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: Yes
Some groups entirely in Spanish: No

## Teachers

Xavier Mora Giné

## Prerequisites

The subject does not officially require any prerequisite, but it is assumed that the student has completed and passed the subjects of "Algebra" and "Differential and integral calculus" of the first year. It is required to have practice in differentiating and integrating one-variable functions.

## Objectives and Contextualisation

It is a basic subject that introduces two of the most important mathematical tools for modeling and solving real problems that appear in engineering: differential equations and vector analysis. It is intended that the student:

- Be able to use the basic analytical methods to obtain solutions of differential equations.

- Be able to distinguish the differential equations that can be solved with analytical methods from those that require numerical methods.

- Be able to extract qualitative information of the solutions of a differential equation of the first order from the vector field of directions.

- Be able to understand the role of differential equations in the mathematical modeling of real problems and be able to build this model in simple situations.

- Gets familiar dealing with functions of several variables and vector fields.

- Be able to deal with curves and surfaces in space and the equations that describe them.

- Understands the meaning of the basic concepts of vector analysis.

- Learns to use the vector analysis tools to identify and calculate physical magnitudes.

- Understands the theorems of vector analysis and their use in the formulation of some physical theories.

## Competences

- Apply relevant knowledge of the basic sciences, such as mathematics, chemistry, physics and biology, and the principles of economics, biochemistry, statistics and material science, to comprehend, describe and resolve typical chemical engineering problems.
- Develop personal work habits.
- Develop thinking habits.
- Work in a team.

## Learning Outcomes

1. Apply the basic concepts of algebra to problem solving.
2. Apply the methods and basic concepts of differential and integral calculus of a variable to the description and calculation of magnitudes.
3. Apply the methods for solving differential equations to the analysis of deterministic phenomena.
4. Critically evaluate the work done.
5. Develop a capacity for analysis, synthesis and prospection.
6. Develop critical thinking and reasoning
7. Develop independent learning strategies.
8. Develop scientific thinking.
9. Identify, analyse and calculate magnitudes in the area of engineering using calculation tools in different variables.
10. Identify, describe and apply basic mathematical and statistical concepts.
11. Manage available time and resources. Work in an organised manner.
12. Work autonomously.
13. Work cooperatively.

## Content

A. Ordinary differential equations.
1. First-order differential equations. Solutions and initial value problems. Resolution by elemental methods: separable equations, linear equations, solutions by substitution.
2. Linear equations of order 2 (and higher) with constant coefficients. Homogeneous linear equations. Non-homogeneous linear equations. Method of indeterminate coefficients.
3. Systems of differential equations of first order. Homogeneous and non-homogeneous linear systems.

B. Vector analysis.
1. Vector functions. Curves in space. Tangent and normal vectors.
2. Functions of several variables. Curves and level surfaces. Partial derivatives Gradients and directional derivatives. Chain rule. Tangent planes. Maximum and minimum values.
3. Multiple integration. Double integrals on elementary domains. Iterated integrals. Triple integrals Applications of the double and triple integrals. Change of variables.
4. Line and surface integrals. Vector fields. Rotational and divergence. Integral lines. Theorem of Green. Theorem of divergence

## Methodology

In the learning process it is fundamental the own work of the student, who at all times will have the help of the professor.

The hours of class are distributed in:

Theory: The teacher introduces the basic concepts corresponding to the subject, showing examples of their application. The student will have to complement the explanations of the professors with the personal study.

Problems: Bycompleting sets of exercises, the comprehension and application of the concepts and tools introduced in the theory class is attained . The student will have lists of problems, a part of which will be solved in the problem classes. Students should work on the remaining ones as part of their autonomous work.

Seminars: to reach a deeper understanding of the subject the students work o in group on more complex practical problems. Some seminars will deal with computer-aid approach to solving problems.

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 | | | |
| Solving problems class | 15 | 0.6 | 3, 7, 9 |
| Theory class | 30 | 1.2 | 3, 9 |
| Type: Supervised | | | |
| Seminars | 5 | 0.2 | 3, 7, 9 |
| Type: Autonomous | | | |
| Personal Study | 30 | 1.2 | 3, 7, 9 |
| Solving problems | 63 | 2.52 | 3, 7, 9 |

## Assessment

A continuous assessment is performed based on four controls:

a) Two written tests combining theory and problems, one P1 related to part A, another P2 related to part B.

b) Submission of two sets of exercises, one LL1 on part A, another LL2 on part B. Can be completed at home and uploaded to Campus Virtual. Their mean is LLP.

Submissions in b) are manadatory, with no resit assesment.

If both P1, P2 have been attended, a grade C1 is generated according to C1=(0,20)LLP+(0,40)(P1+P2). If C1 is at least 5, the final grade is C1.

Students with C1<5 and having submitted b) and students willing to improve their grade, may attend a resit exam, with grade R.

The final grade C2 after the resit exam is C2=(0,20)LLP+(0,80) R.

For students improving their grade, the final score is MAX(C1,C2).

## Assessment Activities

| Title | Weighting | Hours | ECTS | Learning Outcomes |
|---|---|---|---|---|
| Mid-term exam combining theory and problems of part A | 40% | 2 | 0.08 | 1, 3, 2, 8, 5, 6, 9, 10 |
| Mid-term exam combining theory and problems of part B | 40% | 2 | 0.08 | 1, 3, 2, 8, 5, 6, 9, 10 |
| Submission of exercise sets part A | 10% | 1.5 | 0.06 | 3, 4, 7, 11, 9, 13, 12 |
| Submission of exercise sets part B | 10% | 1.5 | 0.06 | 3, 4, 7, 11, 13, 12 |

## Bibliography

Main:

Dennis G. Zill, Michael R. Cullen. Ecuacions diferenciales con problemas de valores en la frontera (sisena edició). International Thompson editores, México 2006.

S. L. Salas, E. Hille. Cálculo de una y varias variables. Ed. Reverté, 1994.

J.Bruna, Set of notes available in Campus Virtual.

Complementary

R.K. Nagle, E.B. Saff, A.D. Snider. Ecuaciones diferenciales y problemas con valores en la frontera (tercera edició). Addison-Wesley. 2001.

R. Martínez. Models amb equacions diferencials. Materials UAB. 2004.

## Software

None is needed