COMILLAS
UNIVERSIDAD PONTIFICIA
ICAI ICADE CIHS

Syllabus
2025 - 2026

GENERAL INFORMATION

Data of the subject	
Subject name	Mathematical Analysis and Vector Calculus
Subject code	DMA-IMAT-102
Mainprogram	Bachelor's Degree in Mathematical Engineering and Artificial Intelligence
Involved programs	Grado en Ingeniería Matemática e Inteligencia Artificial [First year]
Level	Reglada Grado Europeo
Quarter	Anual
Credits	12,0 ECTS
Type	Básico
Department	Department of Applied Mathematics
Coordinator	Manuel Villanueva Pesqueira

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DESCRIPTION OF THE SUBJECT

Contextualization of the subject

Prerequisites

This course is an introduction to One-Variable Calculus and Vector Calculus. It focuses on providing the basic tools from these fields to be used in technical topics, and in showing some of their applications in the engineering field. All the contents will be analyzed including several examples taken from the real life or other sciences like physics, economics, etc. The theoretical classes complement each other with practical sessions in the laboratory where the problems are solved using the computer.

Basic knowledge of Real Analysis is required for attending this course.

Course contents

Contents

Real and complex numbers. Elementary functions.

1. Limits and continuity. Definitions, properties and theorems.
2. Differentiation. The mean value theorem. L'Hopital Rule. Taylor polynomials. Taylor formula. Applications of differentiation: increasing and decreasing intervals, concavity, local and global maxima and minima. Optimization problems.
3. Integration: definition and properties. The Fundamental Calculus Theorem. Improper integrals. The Eulerian functions. Applications of definite integral: area between two curves, length of an arc of curve and volumes.
4. Real number sequences. General definitions, properties and limits. Monotone sequences and bounded sequences.
5. Infinite series: general definitions and properties. Positive series: definition, properties and convergence. Alternating series. Sum of series: exact sum and approximate sum.
6. Interpolation. Statement of the problem. Lagrange intepolation. Piecewise linear interpolation. Hermite interpolation. Splines.

Part I: One-variable Calculus and Real Analysis

1. Real and complex numbers. Elementary functions.
2. Brief notions of topology. Metric spaces.
3. Real number sequences. General definitions, properties and limits. Monotone sequences and bounded sequences.
4. Infinite series: general definitions and properties. Positive series: definition, properties and convergence. Alternating series. Sum of series: exact sum and approximate sum.
5. Limits and continuity. Definitions, properties and theorems.
6. Differentiation. The mean value theorem. L'Hopital Rule. Taylor polynomials. Taylor formula. Applications of differentiation: increasing and decreasing intervals, concavity, local and global maxima and minima. Optimization problems.
7. Integration: definition and properties. The Fundamental Calculus Theorem. Improper integrals. The Eulerian functions. Applications of definite integral: area between two curves, length of an arc of curve and volumes.

Part II: Multivariable Calculus

8. Limits and continuity for vector and scalar valued functions.
9. Partial and directional derivatives. The gradient vector. Differentiability. Tangent Plane and linear approximations.
10. Composition of functions. The Chain Rule. Implicit and inverse functions.
11. Maxima and minima. Lagrange multipliers.
12. Multiple integrals: double and triple integrals. Definition and properties. Changes of variable and symmetries.

Laboratory

There will be six 1-hour sessions during the course, between the third and the last lecture week.

1. Introduction to the software *Matlab (LiveScript)*.
2. Interpolation methods. Applications.
3. Taylor polynomials. Integral Calculus. Applications.
4. Limits. Partial and directional derivatives. Composition of functions.
5. Maxima and minima. Lagrange multipliers.
6. Double integral. Application to centers of mass

EVALUATION AND CRITERIA

The use of AI to produce full assignments or substantial parts thereof, without proper citation of the source or tool used, or without explicit permission in the assignment instructions, will be considered plagiarism and therefore subject to the University's General Regulations.

Evaluation activities	Evaluation criteria	Weight
Theoretical-practical exams: • Short continuous assessment tests (10%) • Mid term exams (1.5-hour long) (25%)	Incluir breve descripción	80

• Final term exams (65%)		
Evaluation of the experimental wok: • Practice exam with MATLAB (at the end of the second semester)	Incluir breve descripción	10
Maths Team Contest (MTC)	Incluir breve descripción	10

Grading

Incluyo el Grading de Cálculo GITI. Modifícalo brevemente para ajustarlo a las características de iMAT. Haz una descripción mucho más light que la versión en castellano.

- The grade obtained in the partials/final exams must be at least 4 over 10 to take into account the previous ponderations of the overall assessment criteria. In other case, the term overall grade will be the grade obtained in the exam.
- The final second term exam will only cover the contents taught in the second term, if the first term overall grade is at least 4 over 10. In other casa, it will cover all the contents of the course.
- The following conditions must be accomplished to pass the course:
  - If the first term overall grade was at least 4, then the second term overall grade must be at least 4 over 10 and the average of both overall grades (first and second terms) must be at least 5 over 10.
  - If the first term overall grade was less than 4, then the second term overall grade must be at least 5 over 10.

BIBLIOGRAPHY AND RESOURCES

Basic References

Textbooks:

- García, A., García, F., López, A., Rodríguez, G., Villa, A. de la. Calculo I: Teoría y problemas de análisis matemático en una variable (3ª edición). CLAG, 2007.
- García, A., López, A., Romero, S., Rodríguez, G., Villa, A. de la. Calculo II: Teoría y problemas de funciones de varias variables (2ª edición). CLAG, 2006.
- Stewart, J., Multivariable Calculus (7th edition). Cengage Learning. 2011,