

CALCULUS FOR COMPUTER SCIENCE

**Grado en Computación e Inteligencia Artificial / Bachelor in
Computer Science and Artificial Intelligence BCSAI SEP-2025
CACC-CSAI.2.M.A**

Area Mathematics

Number of sessions: 30

Academic year: 25-26

Degree course: SECOND

Number of credits: 6.0

Semester: 1º

Category: BASIC

Language: English

Professor: **CARLOS GORDON**

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Bachelor's in mathematics, studied at the Complutense University of Madrid and KTH Stockholm. With over 10 years of teaching experience at both university and high school levels, he has devoted his career to sharing his passion for mathematics. He is also an instructor of digital competence for teachers in the Community of Madrid. His research interest lies in the application of neuroscience tools such as growth mindset, and deep learning algorithms in the field of education.

Office Hours

Office hours will be on request. Please contact at:

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SUBJECT DESCRIPTION

The connection between mathematics and computer science is remarkable. Moreover, early computer science was strongly influenced by the work of mathematicians such as Kurt Gödel, Alan Turing, John von Neumann, Rózsa Péter and Alonzo Church among others. The interchange of ideas between mathematics and computer science has been prolific since the very beginning of computer science until our days. Thus, mathematics has become one of the main tools a computer scientist has to master. Among all the branches of mathematics in this subject we will focus on calculus. Calculus will be a stepping stone towards mathematical, formal and abstract reasoning. The student will learn the most intriguing techniques and applications involving limits, derivatives and integrals. We will uncover the applications of calculus to the study of algorithm complexity and other topics in computer science. In this subject we will combine pure mathematical thinking with the solution of mathematical problems using computers.

LEARNING OBJECTIVES

The main objective of this course is to set the **foundations of mathematical and analytical thinking**, and to develop the necessary **abstract reasoning** and computational tools that the students will use during the rest of their trajectory.

At the end of the course, students should be able to:

- Use abstract reasoning.
- Re-formulate real-world problems in mathematical language.
- Master the the key concepts of mathematical analysis: limit, derivative, integral...
- Make complex computations involving derivatives and integrals.
- Solve basic problems in optimization.

Additionally, the course will help in the acquisition or reinforcement of generic skills:

- The ability to summarize and present information in a meaningful and accurate way.
- The ability to isolate the core questions from the more superfluous ones.
- The ability to quickly identify the tools that need to be used in a particular problem.

TEACHING METHODOLOGY

IE University teaching method is defined by its collaborative, active, and applied nature. Students actively participate in the whole process to build their knowledge and sharpen their skills. Professor's main role is to lead and guide students to achieve the learning objectives of the course. This is done by engaging in a diverse range of teaching techniques and different types of learning activities such as the following:

Learning Activity	Weighting	Estimated time a student should dedicate to prepare for and participate in
Lectures	20.0 %	30.0 hours
Discussions	13.3 %	20.0 hours

Exercises in class, Asynchronous sessions, Field Work	20.0 %	30.0 hours
Group work	20.0 %	30.0 hours
Individual studying	26.7 %	40.0 hours
TOTAL	100.0 %	150.0 hours

AI POLICY

Generative artificial intelligence (GenAI) tools may be used in this course, with the goal of developing an informed critical perspective on potential uses and generated outputs.

However, be aware of the limits of GenAI in its current state of development:

-If you provide minimum effort prompts, you will get low quality results. You will need to refine your prompts to get good outcomes. This will take work.

-Don't take ChatGPT's or any GenAI's output at face value. Assume it is wrong unless you either know the answer or can cross-check it with another source. You are responsible for any errors or omissions. You will be able to validate the outputs of GenAI for topics you understand.

-AI is a tool, but one that you need to acknowledge using. Failure to do so is in violation of academic honesty policies. Acknowledging the use of AI will not impact your grade.

Suggested format to acknowledge the use of generative AI tools:

I acknowledge the use of [AI systems link] to [specify how you used generative AI]. The prompts used include [list of prompts]. The output of these prompts was used to [explain how you used the outputs in your work].

PROGRAM

***Disclaimer:** The following description of the material covered is tentative. An attempt will be made to cover all listed topics. However, the pace of the classes will depend on group performance, which may introduce some variations in the syllabus.*

SESSION 1 (LIVE IN-PERSON)

Introduction to the course.

- Overview of the contents, materials, methodology and grading.
- Preliminary concepts.
- Applications and examples.

SESSION 2 (LIVE IN-PERSON)

Limits

- Concept, idea, and formal definition.
- Limit computation.

SESSION 3 (LIVE IN-PERSON)

Indeterminate forms

- Limit computation. Indeterminate forms.
- Squeeze Theorem.

SESSION 4 (LIVE IN-PERSON)

Limits: further applications

- Asymptotes.
- L'Hôpital's rule.
- Examples using Wolfram Alpha.

SESSION 5 (LIVE IN-PERSON)

Continuity

- Definition.
- Discontinuity types.
- Bolzano Theorem.
- Examples using Wolfram Alpha.

SESSION 6 (LIVE IN-PERSON)

Derivatives

- Concept and formal definition as a limit.
- Review of computation rules.
- Implicit differentiation.
- Logarithmic differentiation.

SESSION 7 (LIVE IN-PERSON)

High-order derivatives

- Applications.
- Tylor series and residual.
- Big O and little o notation.

SESSION 8 (LIVE IN-PERSON)

Review and Quiz.

SESSION 9 (LIVE IN-PERSON)

Sequence

- Concept of sequence.
- Definition of limits of a sequence.
- Techniques for computing limits of sequences.
- Examples and applications.

SESSION 10 (LIVE IN-PERSON)

Sequence (cont)

- Concept of sequence.
- Definition of limits of a sequence.
- Techniques for computing limits of sequences.
- Examples and applications

SESSION 11 (LIVE IN-PERSON)

Series

- Concept of series.
- Limit of series. Techniques for computing limits of series. Power series.
- Divergent series.

SESSION 12 (LIVE IN-PERSON)

Integrals

- Antiderivative and indefinite integrals.
- Advanced methods of integration.

SESSION 13 (LIVE IN-PERSON)

Integrals

- Definite integral and area. Riemann`s sums as limits.
- Fundamental Theorem of Calculus.
- Examples and applications using python.

SESSION 14 (LIVE IN-PERSON)

Improper Integrals

- P-integrals
- Convergence, and comparison test.

SESSION 15 (LIVE IN-PERSON)

Review for the midterm

SESSION 16 (LIVE IN-PERSON)

Midterm

SESSION 17 (LIVE IN-PERSON)

Numerical methods

- Numerical approximation of definite integrals (Simpson's and Trapezoidal Rules).
- Newton's method.
- Implementation of numerical algorithms in python.

SESSION 18 (LIVE IN-PERSON)

Functions of several variables

- Review of previous knowledge. Concept and visualizing functions.
- Level sets and curves.
- Partial derivatives.
- Gradient.
- Directional derivatives.

SESSION 19 (LIVE IN-PERSON)

Chain Rule for functions of several variables

- Definition.
- Particular cases.
- Applications and Backpropagation algorithm.

SESSION 20 (LIVE IN-PERSON)

Optimization

- High-order derivatives for several variables.
- Unconstrained optimization.
- Gradient descent algorithm and implementation.

SESSION 21 (LIVE IN-PERSON)

Constrained Optimization

- Lagrange multipliers. Graphical interpretation.
- Examples and applications.
- Implementation in python.

SESSION 22 (LIVE IN-PERSON)

Review and Quiz

SESSION 23 (LIVE IN-PERSON)

Double Integrals

- Rectangular regions.
- Cavalieri principle.
- Fubini's Theorem.

SESSION 24 (LIVE IN-PERSON)

Triple Integrals

- Fubini's Theorem for triple integrals.
- Volume as a triple integral.

SESSION 25 (LIVE IN-PERSON)

Change of Variables in Multiple Integrals

- Polar coordinates.

SESSION 26 (LIVE IN-PERSON)

Change of Variables in Multiple Integrals

- Cylindrical coordinates.
- Spherical coordinates.

SESSION 27 (LIVE IN-PERSON)

Review and quiz

SESSION 28 (LIVE IN-PERSON)

Vector valued functions

- Parametrized curves.
- Vector fields.
- Integrals over curves.
- Arc length.

SESSION 29 (LIVE IN-PERSON)

Conservative Fields

- Curl and divergence.
- Conservative fields.
- Fundamental Theorem of integrals over curves.
- Potential functions.

SESSION 30 (LIVE IN-PERSON)

Final exam

EVALUATION CRITERIA

criteria	percentage	Learning Objectives	Comments
Final Exam	30 %		It is worth 30% of the overall grade. You need to score at least 3.5 on the final exam to pass the overall course, even if you have already passed the course through the other course assessments.
Intermediate tests	30 %		The mid-term exam and quizzes are worth 30% of the overall grade.
Individual work	30 %		Each module has its own problem set including several exercises. The student is expected to work on them and to turn in selected exercises that will be announced throughout the course.
Class Participation	10 %		Students are expected to participate actively during lectures with questions and remarks. Class grade will be based also on participation and class conduct. There may be a penalty if you create a disruption or talk excessively during class.T

RE-SIT / RE-TAKE POLICY

Each student has four chances to pass any given course distributed over two consecutive academic years: ordinary call exams and extraordinary call exams (re-sits) in June/July.

Students who do not comply with the 80% attendance rule during the semester will fail both calls for this Academic Year (ordinary and extraordinary) and have to re-take the course (i.e., re-enroll) in the next Academic Year.

Evaluation criteria:

- Students failing the course in the ordinary call (during the semester) will have to re-sit the exam in June / July (except those not complying with the attendance rule, who will not have that opportunity and must directly re-enroll in the course on the next Academic Year).
- The extraordinary call exams in June / July (re-sits) require your physical presence at the campus you are enrolled in (Segovia or Madrid). There is no possibility to change the date, location or format of any exam, under any circumstances. Dates and location of the June / July re-sit exams will be posted in advance. Please take this into consideration when planning your

summer.

- The June / July re-sit exam will consist of a comprehensive exam. Your final grade for the course will depend on the performance in this exam only; continuous evaluation over the semester will not be taken into consideration. Students will have to achieve the minimum passing grade of 5 and can obtain a maximum grade of 8.0 (out of 10.0) – i.e., “**notable**” in the in the re-sit exam.
- Retakers: Students who failed the subject on a previous Academic Year and are now re-enrolled as re-takers in a course will be needed to check the syllabus of the assigned professor, as well as contact the professor individually, regarding the specific evaluation criteria for them as retakers in the course during that semester (ordinary call of that Academic Year).

The maximum grade that may be obtained in the retake exam (3rd call) is 10.0.

After ordinary and extraordinary call exams are graded by the professor, you will have a possibility to attend a review session for that exam and course grade. Please be available to attend the session in order to clarify any concerns you might have regarding your exam. Your professor will inform you about the time and place of the review session. Any grade appeals require that the student attended the review session prior to appealing.

Students failing more than 18 ECTS credits in the academic year after the June-July re-sits will be asked to leave the Program. Please, make sure to prepare yourself well for the exams in order to pass your failed subjects.

In case you decide to skip the opportunity to re-sit for an exam during the June / July extraordinary call, you will need to enroll in that course again for the next Academic Year as a re-taker and pay the corresponding extra cost. As you know, students have a total of four allowed calls to pass a given subject or course, in order to remain in the program.

BIBLIOGRAPHY

Recommended

- Stewart, J. (2016). *Calculus*. 8th. Cengage Learning. ISBN 978128574155 (Digital)
- Marsden, J. E. & Tromba, A. J.. *Vector Calculus*.. 6th. W. H. Freeman. ISBN 978142922404 (Digital)
- Adams, R. A., & Essex, C.. (2018). *Calculus: A Complete Course*. 9th. Pearson. ISBN 9780134154367 (Digital)

BEHAVIOR RULES

Please, check the University's Code of Conduct [here](#). The Program Director may provide further indications.

ATTENDANCE POLICY

Please, check the University's Attendance Policy [here](#). The Program Director may provide further indications.

ETHICAL POLICY

Please, check the University's Ethics Code [here](#). The Program Director may provide further indications.

