

esade

RAMON LLULL UNIVERSITY

# Advanced Mathematics

6 ECTS

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## 1. Course description

This is a course on advanced mathematics, covering advanced multivariable calculus, perturbative approximations, numerical approximations, differential equations and function spaces. Its central objective is to develop logical reasoning and analytical skills in the understanding and use of advanced mathematical methods for complex quantitative modeling and problem solving. It will rely centrally on student's engagement with reading and working through the textbook, or other required reading materials, as the primary method of encountering and gaining the knowledge of the course material. It will build upon the concepts that students have previously learned in their introductory Calculus and Algebra course. It will provide students with a solid mathematical foundation for future advanced study in fields such as data science, quantitative finance or any other STEM field in which they choose to specialize.

Pre-requisite: Calculus and Algebra.

## 2. Learning objectives

After completing this course, students will be able to:

- Use advanced mathematical reasoning, developed through reading and practice.
- Recognize and fluently employ advanced mathematical terminology and language.
- Understand, relate and use the concepts and models of advanced multivariable calculus, perturbative approximations, numerical approximations, differential equations and function spaces; implement these in abstract/theoretical as well as practical applications.
- Communicate clearly and in a logically consistent sequence the concepts and methods involved in advanced mathematical modeling, as well as the results and underlying justifications required to solve advanced mathematical problems.
- Face new problems and situations and identify the right tools to cope with them, in order to build a well-founded solution.
- Connect advanced mathematical methods to concepts and applications in data science, quantitative finance and other STEM fields.

## 3. Contribution to personal development and life skills

Mathematics is based fundamentally on logic. Logic requires ordered reasoning processes. It also requires consistency – that is, the absence of contradictions – in thinking. Doing mathematics, like no other mental discipline, trains thought to be ordered and consistent. These are life skills the importance of which transcends any specific technical aptitude in any particular mathematical task. Taking decisions of any kind, whether professional or personal, requires order in one's thinking and the logical capacity to eliminate contradictions, i.e. achieve consistency, in it. Students will come away from this course with an enriched capacity to do precisely that, and with greater confidence in their own critical reasoning skill for solving any problem, mathematical or otherwise.

## 4. Course format and methodological approach

Students will learn by reading and practicing ahead of class using a textbook or other reading materials. Classes will serve to solidify the studied concepts, fill in gaps, resolve doubts, and do further practice to master the material.

The course will consist of 10 topics (see Section 5 for the detailed content), covered over 10 weeks of class (1 topic per week). The typical workflow for students for Topic N will be:

- **Before the N-th week of class:** Students will read the required reading on Topic N, and attempt the corresponding exercises.
- **During the N-th week of class:** There will be two days of class each week, on Monday and Wednesday. The structure of the classes will be:
  - **Monday:** 08:00-09:20 Second participatory class on Topic (N-1); 09:20-09:30 Break; 09:30-10:30 First lecture on Topic N.
  - **Wednesday:** 10:45-11:45 Second lecture on Topic N; 11:45-11:55 Break; 11:55-13:15 First participatory class on Topic N.

The activities carried out in the two different types of sessions are as follows:

- **Lectures:** sessions with the entire cohort together. During these sessions, the instructor will give a very general summary of the material from the required reading, as well as adding any further relevant content not covered therein, resolving doubts, and doing further examples on the board. Lectures will not provide a structured and exhaustive exposition of the material.
- **Participatory classes:** sessions with the cohort divided into two groups. Students will work in randomly-assigned teams to solve problems and will upload their work in the Moodle at the end of the session as a single PDF file.
- **Outside of class:** Students will prepare for Topic (X+1) by doing the required reading and attempting the exercises.

For 7 out of the 10 topics, including the entire first half of the course, the required reading will be from a textbook, henceforth the main textbook (“the textbook”) for the course:

“*Calculus: Early Transcendentals*” 9th edition, by James Stewart, Daniel Clegg, Saleem Watson (Cengage Learning, 2021).

Note that there are two versions of this book: the metric edition (using metric units) and the regular edition (using imperial units). Either version is equally suitable for this course.

For the other 3 topics (Topics 7, 9 and 10), the reading material will be announced later.

On evaluation activities, students may be evaluated on any material from the required reading as well as any small additions to the material given by the instructor in the lectures, for which the chalkboard will be used. There will be no slides or notes provided.

Regarding those topics for which the required reading is from the textbook, each section therein has exercises at the end of it. Students are invited to work through as many of these

exercises pertaining to the assigned reading as they wish. Note that many exercises ask the same thing just with a different setup (e.g., a different function), so students should exercise their own discernment with regards to the kinds of problems they need to focus on and do more of. Extra practice problems not in the textbook will also be provided, without solutions. If students wish to clarify anything about their solutions to these problems, they are invited to bring it up in class.

Regarding those topics for which the required reading is not from the textbook (Topics 7, 9 and 10), the recommended practice material will also be announced later.

## 5. Course contents

### UNIT 1. Advanced Multivariable Calculus

*Topic 1: Constrained Optimization*

*Topic 2: Integration on  $\mathbb{R}^n$*

### UNIT 2. Perturbative Approximations

*Topic 3: Sequences*

*Topic 4: Series*

*Topic 5: Taylor Approximations*

### UNIT 3. Numerical Approximations

*Topic 6: Numerical Analysis*

*Topic 7: Numerical Optimization*

### UNIT 4. Differential Equations and Function Spaces

*Topic 8: Ordinary Differential Equations*

*Topic 9: Partial Differential Equations*

*Topic 10: Function Spaces*

## 6. Assessment

Students' final grade for Advanced Mathematics will consist of the following elements\*:

### 50% - Students' continuous assessment:

25% - Class participation, interaction and teamwork

20% - Individual assessments

5% - Peer evaluation

### 50% - Final exam

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\* The ESADE Faculty can decide to use another formula to calculate the final grade, as long as the resulting final grade is greater than or equal to the one obtained using the formula described in this document.

## Class participation, interaction and team work

Students are encouraged to participate in both the lectures and participatory sessions, but the focus will be on their level of commitment to their own learning process and that of their teammates. The grade for class participation and teamwork will be based on the sole opinion of the corresponding participatory session instructor, who will consider, among other items, the following<sup>†</sup>:

- Class participation.
- Ethical and proper use of electronic devices.
- Punctuality.
- Team interaction.
- Willingness to learn by doing.

## Individual assessments

Four individual assessments, one corresponding to each Unit, will take place to assess students on their continuous learning and to steer their preparation for the final exam. Each of them will last 30 minutes and will take place at the end of the second participatory session of the last topic of the corresponding Unit. Exceptionally, the individual assessment on Unit 4 will take place at the end of the second participatory session of Topic 9, and will only cover Topics 8 and 9. The four dates are as follows:

Unit 1 Individual Assessment: Monday 23 February.

Unit 2 Individual Assessment: Monday 16 March.

Unit 3 Individual Assessment: Monday 20 April.

Unit 4 Individual Assessment: Monday 4 May.

The questions given in the individual assessments will be of similar style and difficulty range to those students should expect on the final exam.

Students' individual assessment grade will be the average of the best two out of the four individual assessments.

If students are not present for the entire participatory class, the grade of the corresponding assessment will be zero. Retake assessments will be offered only to students who have missed three or four assessments with justification from the program management for at least one or, respectively, two of them: in the former case, one retake assessment for the most recent justified absence, and in the latter case, two retake assessments for the two most recent justified absences. Otherwise, no retake assessments will be offered.

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<sup>†</sup> These items are shown in alphabetical order; no other meaning must be related to the order of appearance in this list.

## Peer Evaluation

The objective of the Peer Evaluation is for each student to assess the members in their team during the participatory classes, considering the following:

- Effort and ability to foster a team dynamic
- Willingness of the student to work on the exercises
- Cooperation with the other team members
- Individual's overall contribution to the team

The peer evaluations will be kept in strict confidence.

## Final exam

A final exam will take place at the end of the course to assess each student's knowledge about the topics covered in the course.

Students will only be able to justify not sitting the final exam in those cases stipulated by the BBA's rules in section 4: *Assessment System* on moving exam dates, with BBA Program Management acceptance.

A **minimum grade of 4/10** on the final exam is required to be able to compute the course grade according to the evaluation scheme above. If this minimum grade is not achieved, the final course grade will be the final exam grade.

Students with an absence for the final exam that is not justified by the BBA Program Management will receive a course grade of NP ("Not Presented").

Paragraph 1 of Section 2.2 of ESADE's *Internal Regulations Governing the Bachelor of Business Administration (BBA) Program* stipulates that: "To be able to sit the final exams in the first call, students need to have attended at least 80% of the respective class sessions."

Students are not allowed to write the final exam if they are absent for more than 50% of class sessions, irrespective of whether their absences are justified by the program management or not. In such a case, their final course grade will be NP.

Those students who are retaking the course without class attendance will only sit the final exam in May. For such students, 100% of the grade for the course will be their grade on this exam.

## Retake Exam (July)

Students that earn a final grade below 5 in the first sitting of the course will have to write a retake exam in July. The continuous assessment will also be taken into consideration for the final grade in this second sitting, with the same weights as in the first sitting, and with the retake exam having a weight of 50%. However, in this case, the continuous assessment can only lower the final grade to 5, but it cannot cause the student to fail the second sitting if the retake exam is passed (i.e., if a grade of 5 or above is obtained on this exam).

Once again, to compute the final grade in the second sitting with the continuous assessment also considered, a minimum retake exam grade of 4 is required. Otherwise, the final grade in the second sitting will be the retake exam grade.

Students are not allowed to write the retake exam if they are absent for more than 50% of class sessions, irrespective of whether their absences are justified by the program management or not. In such a case, their grade on the retake exam will be NP.

## 7. Attendance

Students will be expected to be present in class at the scheduled start time. It is recommended that they arrive a few minutes early to ensure sufficient time for settling in. The door will be locked 5 minutes following the start of each session and will be opened momentarily 10 minutes thereafter to permit late students waiting outside to enter. Such students will be marked as **Late**. Students will be marked **Absent** and will not be allowed to participate in the session if they arrive more than 15 minutes late.

Being Late for a session (either a participatory session or a Lecture) will multiply the session duration by 0.75 in the count of the total time that the student has spent in class. This total divided by the total class time for the entire course will be the student's participation rate, which cannot be lower than 80%.

Occasional absences will not be justified. For prolonged absences, students must provide a valid justification to their program manager. According to BBA rules and regulations, students are obligated to submit these documents within one week of their initial absence. Under no circumstances should such justifications be sent to the professor. Fully justified absences will be excused by the end of the course.

In adherence to ESADE regulations, **attendance is mandatory** for this course. Students will be allowed to miss up to 20% of class hours, including penalizations incurred due to the lateness policy. Students who exceed the absence limit will receive a course grade of NP ("Not Presented").

## 8. Faculty leading the course

Administrative support from the DATA Department:  
Ms. **Mode Guillén** (mode.guillen@esade.edu)

Short bio of the faculty leading the course:

### **Course Coordinator and Participatory Class Instructor (Group 1):**

**Marius Oltean** (marius.oltean@esade.edu) is an Adjunct Professor in the Department of Operations, Innovation and Data Sciences at ESADE, primarily teaching mathematics and data science courses at the bachelor's level. He completed his PhD in theoretical physics in 2019 jointly at the Autonomous University of Barcelona and the University of Orléans, France, focusing on the problems of motion and energy in Einstein's theory of general relativity. Originally from Romania, he also previously studied and worked in Toronto and Montréal, Canada. Marius has worked in teaching mathematics and data science courses for business, engineering, science, and pure mathematics students at diverse post-secondary levels, including from 2018 at ESADE in the BBA, MBA, and MSc programs.

### **Participatory Class Instructor (Group 2):**

**Francesc Rossell** (francesc.rossell@esade.edu). After graduating in Mathematics at UPC a long time ago, Francesc discovered that his passion for Maths & Statistics could be extended to Finance, Business Administration, Teaching (he holds a Masters' degree on each of these fields) and even Coaching (he is a Professional Certified Coach and a member of the International Coach Federation). He combines teaching Mathematics, managing projects in Risk Management and Machine Learning (yes, Finance speaks ML too), and coaching people and high-performance teams. He also likes writing (the last book he wrote, in Spanish, can be purchased at <https://shackletonbooks.com/inicio/325-el-infinito.html>) and running, especially in the morning, because "Best decisions can come in the midst of a Marathon". Francesc started teaching at ESADE in 2019, and is currently a Teaching Fellow of this Business School; together with his teaching duties, he is also in charge of coordinating the Capstone Projects of the MSc in Business Analytics and managing the Basic Maths and Stats Test.

**Office hours:** by appointment

## This course is strictly ruled by ESADE's Honour Code

*"I will not lie, cheat or steal to gain an academic advantage. I will respect all ESADE students, faculty and staff with my words and deeds."*

The violations of the ESADE MBA Honor Code include the following:

**Lying:** Lying includes knowingly communicating an untruth in order to gain an unfair academic or employment advantage.

**Cheating:** Cheating includes, but is not limited to, using unauthorized materials to complete an assignment; copying the work of another person; unauthorized providing of materials or information (e.g. proprietary course information) to another person; plagiarism; unauthorized providing of materials or information to another person during an exam. All communications, written, oral or otherwise, among students during examinations, are forbidden, as is the use of notes, books, computers, calculators or other written material except when approved by the instructor.

**Stealing:** Stealing includes, but is not limited to, taking the property of another member of the ESADE community without permission, defacing or vandalizing the property of the ESADE Business School, or the misuse of ESADE resources.

**Respect for others and professional conduct:** Respect for others includes treating all ESADE students, staff, faculty and external contacts connected to the school with politeness and cordiality, refraining from using abusive language or physical violence.

Upon witnessing a violation of the Honour Code, a student has a **moral obligation** to inform the student whose conduct is believed to be in violation of the Code that the Code has been violated. Each member of the ESADE MBA community, as a person of integrity, has a personal obligation to adhere to this requirement, both on campus and when representing ESADE off campus.

Failure to comply with the more explicit guidelines set forth by the Programme's Rules and Regulations can also be considered as breach of the Honour Code.

**Violations of this agreement and will be governed by MBA Programme Management which has the right to exercise any disciplinary action necessary in order to uphold the standards set forth herewith and in the Programme's Rules and Regulations.**

