**Advanced calculus and stochastic processes**

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***COURSE AIMS AND EXPECTED LEARNING OUTCOMES***

*Course aims*

The course aims to provide students with sophisticated mathematical tools necessary for understanding banking, financial and insurance models, whose phenomena under consideration are expressed in quantitative terms.

*Expected learning outcomes*

The expected learning outcomes are the ability to read, interpret and manipulate the quantitative aspects of banking, financial and insurance phenomena.

At the end of the course, students will possess technical skills accompanied by an understanding of their specific applications. In particular:

1. *They will be familiar with* the mathematical tools necessary to to read, interpret and manipulate the quantitative aspects of banking, financial and insurance phenomena.
2. *They will be able to* solve differential equations, recognize a martingale in discrete or continuous time, analyze a Markov chain in discrete time
3. recognize which tool to use to model concrete situation
4. *They will be able to* understand and interpret a problem and its data, identifying the appropriate mathematical tool needed to model concrete situation.
5. *They will be able to* describe and analyze a model in clear and rigorous language.

***COURSE CONTENT***

The course syllabus is structured as follows:

First Module *(4 credits)*

Linear differential equations and systems with constant coefficients: solutions by means of characteristic equation or by means of Laplace transform.

Differential equation with separation of variables.

Second Module *(5 credits)*

Conditional expectation.

Stochastic processes in discrete times: marttingales, submartingales and supermartingales; stopping times and optional sampling theorem.

Time-homogenoeus Markov chains in discrete times: graph representation, transition matrix, classification of states, absorbing and stationary probabilities.

Stochastic processes in continuous time: martingales, submartingales and supermartingales; Wiener process (brownian motion) and Poisson process.

***READING LIST***

Selected materials (slides, exercises, mock exams) will be made available on the course Blackboard site.

***TEACHING METHOD***

The course will consist of classroom lectures in which theoretical content will be presented, accompanied by extensive examples and exercises with a focus on financial and insurance applications.

### **ASSESSMENT METHOD AND CRITERIA**

*Assessment methods*

The exam will be a written assessment consisting of open-ended questions and/or multiple-choice questions, both theoretical and applied, covering the topics of the entire course (first and second modules). The point value of each question will be indicated in the exam text. The maximum score is 32 points. The points obtained on the written exam, rounded to the nearest integer (rounded up if the decimal part is greater than or equal to 0.5), will constitute the final mark obtained in the course. Honors marks will be awarded in the event the student obtains a final rounded score of at least 31. A mock test with the same format as the actual exam will be published on Blackboard.

Alternatively, the exam can be passed by taking two partial exams, one for each module, administered at the end of the respective module. Further details regarding the structure and procedure of the partial exams will be provided during the course and on the Blackboard platform.

*Evaluation criteria*

During the exam, students are expected to demonstrate knowledge they have acquired in the course. The ability to solve the exam exercises will demonstrate the student’s level of learning achieved, as well as their ability to apply knowledge and exercise independent judgment. The presentation of solutions will showcase their ability to communicate using technical language.

***NOTES AND PREREQUISITES***

*Notes*

Attendance, although not mandatory, is strongly encouraged.

Course materials and additional resources for exam preparation will be made available online.

Detailed information regarding organization and exam procedures will be provided during the course and on the Blackboard platform.

*Prerequisites*

Students are expected to have basic knowledge of Calculus I and II and probability theory.

*Office hours*

The time and location for office hours will be published on the instructors’personal pag