UAB
Universitat Autònoma de Barcelona

Stochastic Processes

2026/2027

Code: 100116
Credits: 6

Degree programme	Type	Course
Mathematics	OP	4

Contact lecturer

Name : Rosario Delgado De la Torre

Email : rosario.delgado@uab.cat

Group languages

You can consult this information at the end of the document.

Prerequisites

As a general requirement, in order to be able to follow this subject, good knowledge is required at the practical level of linear algebra, analysis and calculus or, more specifically, matrices, integration and series. As more specific requirements, it is necessary to have previously studied a course in Probability and Stochastic Modeling.

Objectives

The aim of this subject is, on the one hand, to introduce the student in the part of the theory of probability called theory of stochastic processes, whose purpose is to study the random phenomena that evolve over time or in the space We will see the basic generalities of these models and we will study some specific models.

The discrete Markov chains will be studied in general and in the particular case of the random walk. We will also study the continuous-time Markov chains, such as the Poisson process or the birth and death processes. Finally we will also introduce the Brownian motion.

Learning outcomes

1. Effectively use bibliographies and electronic resources to obtain information.
2. Students must have and understand knowledge of an area of study built on the basis of general secondary education, and while it relies on some advanced textbooks it also includes some aspects coming from the forefront of its field of study.
3. Students must be capable of communicating information, ideas, problems and solutions to both specialised and non-specialised audiences.
4. Students must develop the necessary learning skills to undertake further training with a high degree of autonomy.
5. Generate innovative and competitive proposals for research and professional activities.
6. Actively demonstrate high concern for quality when defending or presenting the conclusions of one's work.
7. Devise demonstrations of mathematical results in the field of probability and statistics.

Contents

1. Introduction to stochastic processes.
2. Discrete time Markov chains.

3. Birth-and-death processes.
4. Queueing systems.
5. The Brownian motion process.

Learning activities and methodology

Title	Hours	ECTS	Learning outcomes
Theory classes	28	1.12	1, 2, 6, 7
Problem classes	13	0.52	1, 2, 4, 5, 6, 7
Prepare exams	20	0.8	1, 2, 7
Study of the theory and resolution of problems	65	2.6	1, 2, 4, 5, 6, 7
Seminars	6	0.24	2, 4, 5, 6, 7

This is a semester-long course consisting of two hours of lectures and one hour of problem-solving sessions per week of face-to-face teaching. In addition, there will be three seminar sessions of two hours each.

The introduction of theoretical concepts in the lecture sessions is essential for students to understand and master the foundations of the theory of stochastic processes presented in this course. Knowledge of the concepts introduced in lectures, the statements of propositions and theorems, as well as illustrative examples and applications, is indispensable for students to be able to solve related problems using similar methodologies during the problem-solving sessions.

The course follows a definition-theorem-proof-application structure, as this approach enables students to understand and follow the reasoning underlying mathematical theory. It also helps them appreciate the role played by the different elements involved in the proofs of new mathematical results, as well as the assumptions that must be imposed. Particular emphasis is placed on fostering a critical attitude towards mathematical statements and on developing intuition regarding the suitability of different mathematical models for a wide variety of real-world situations, including applications in physics, biology, economics, and other fields. To this end, students will work on applied problems from different areas in which mathematical modelling plays a central role.

The problem-solving sessions will include both theoretical and practical exercises.

In addition, the seminar sessions will be devoted to practical work using the free software environment R (RStudio) to simulate some of the stochastic processes introduced in the lectures. Simulation is a particularly useful tool because it allows students to explore the behaviour of a system when exact analysis is difficult, to verify theoretical results, and to develop intuition about the phenomena being modelled.

USE OF ARTIFICIAL INTELLIGENCE (AI): In this course, the use of Artificial Intelligence (AI) technologies is permitted exclusively for support tasks, such as literature or information searches, text editing and proofreading, or translation. Students must clearly identify, where applicable, any parts of their submitted work that have been generated with the assistance of such technologies, specify the tools used, and include a critical reflection on how these tools have influenced both the process and the final outcome of the activity.

A lack of transparency regarding the use of AI in this assessed activity will be considered a breach of academic integrity and may result in a partial or total penalty in the grade for the activity, as well as more severe

disciplinary measures in serious cases.

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.

Assessment

Continuous assessment activities

Title	Weight	Hours	ECTS	Learning outcomes
Test (PAC1)	35%	4	0.16	2, 3, 4, 6, 7
Exam	50%	4	0.16	2, 4, 6, 7
Resit exam	85%	4	0.16	1, 2, 4, 5, 6, 7
Deliveries of problems and/or practical exercices (PAC2)	15%	6	0.24	1, 2, 4, 5, 6, 7

The assessment of the course will be based on the following components (the percentages indicate their contribution to the final grade):

- PAC1 (theory/problem-solving test, held midway through the semester): 35%
- PAC2 (delivery of problem sets and/or practical exercises, carried out in class): 15%
- Exam (theory and problem-solving, held at the end of the semester): 50%

If the grade obtained in any of these assessment components is below 3.5 out of 10, it will be considered as 0 when calculating the final grade.

If the final grade is below 5.0 out of 10, and only in this case, students may sit the Resit exam, which accounts for 85% of the final grade.

The remaining 15% corresponds to the grade obtained in PAC2, which is not recoverable.

Single Assessment

Students who have opted for the single assessment system will be required to take a final assessment consisting of a comprehensive examination covering theory, problem-solving, and practical work in R.

Bibliography

- An excursion into Markov chains. X. Bardina and M. Ferrante. Springer, *to appear*.
- Introduction to Probability Models. Sheldon M. Ross. 2024 (Thirteenth edition). Hard copy (library of Science and Technology)
- Introduction to Stochastic Processes. Gregory F. Lawler. 2006 (Second Edition). On-line (library of Science and Technology)
- Adventures in Stochastic Processes. Sidney I. Resnick. 1992. Hard copy (library of Science and Technology)
- Simulation. Sheldon M. Ross. 2023 (Sixth edition). On-line (library of Science and Technology)

Software

RStudio

Course groups and languages

The information provided is provisional until November 30. After this date, you will be able to consult the language of each group through this link. To access the information, you will need to enter the course CODE

Type of teaching	Group	Language	Semester	Shift
(TE) Theory	1	Catalan	first semester	morning-mixed
(PAUL) Classroom practices	1	Catalan	first semester	morning-mixed
(SEM) Seminars	1	Catalan	first semester	afternoon