Universitat Autònoma de Barcelona

**2020/2021**

# Stochastic Processes

Code: 104859
ECTS Credits: 6

| Degree | Type | Year | Semester |
|---|---|---|---|
| 2503852 Applied Statistics | OB | 2 | 2 |

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

## Contact

Name: Lluís Antoni Quer Sardanyons
Email: LluisAntoni.Quer@uab.cat

## Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

## Teachers

Josep Maria Burgués Badía
Maria Jolis Giménez

## Prerequisites

It is advisable to have successfully completed the following mandatory courses: Càlcul 1, Àlgebra lineal, Introducció a la probabilitat, Eines informàtiques per a l'estadística i Probabilitat.

## Objectives and Contextualisation

We introduce the students into the theory of the stochastic processes, with a special emphasis on how they can be used to mathematically model several examples and real situations. More precisely, the main part of the course is devoted to deal with Markov chains, which provide one of the more important tools in stochastic modeling, with a lot of applications, for example in biology, medicine or queuing theory. We introduce discrete-time and continuous-time Markov chains and, due to its highly level of applicability, we specially treat the Poisson process, as a example of birth and death processes, and branching processes. During the course mathematical proofs will be mostly avoided, although we give a reference for them, and we focus on the applications of the methods and techniques to particular examples. Indeed, one of the principal aims consists that students learn to choose the convenient method in order to model some phenomenon, and also to implement it as well as to extract conclusions.

Another major objective is to introduce the Brownian motion, which represents the paradigmatic example of stochastic process with non-countable state space. Its definition will be motivated, emphasizing all variety of fields where Brownian motion can be applied, and some of its properties will be studied. We also introduce some processes related to Brownian motion, such as the Brownian bridge and the geometric Brownian motion.

Finally, the last aim of the course is that the students learn to use the software R in order to simulate different types of stochastic processes and extract the pertinent conclusions in view of the phenomenon that is being modeled.

## Competences

- Select statistical models or techniques for application in studies and real-world problems, and know the tools for validating them.
- Summarise and discover behaviour patterns in data exploration.

## Learning Outcomes

1. Identify the different attributes of a Markov chain.
2. Identify the time distribution between two consecutive arrivals at the system in stochastic processes.
3. Recognise the need to use models of stochastic processes.

## Content

1. Introduction to stochastic processes

2. Discrete-time Markov chains

3. Branching processes

4. Poisson process

5. Continuous-time Markov chains

6. Brownian motion

## Methodology

The theoretical and problem sessions will be carried out in a classroom. These sessions will be devoted to the presentation of theoretical aspects and the solution of problems. Problem lists will be supplied along the course.

The computer sessions will be carried out in a computer room. In these sessions, studens will solve some problems related to the methods introduced during the course using R

The gender perspective goes beyond the contents of courses, since it implies also a revision of teaching methodologies and interactions between students and lecturers, both inside and outside the classroom. In this sense, participative teaching methodologies that give rise to an equality environment, less hierarchical in the classroom, avoiding examples stereotyped in gender and sexist vocabulary, are usually more favorable to the full integration and participation of female students in the classroom. Because of this, their effective full integration and participation of female students in the classroom. Because of this, their effective implementation will be attempted in this course.

## Activities

| Title | Hours | ECTS | Learning Outcomes |
|---|---|---|---|
| Type: Directed | | | |
| Problem classes | 14 | 0.56 | 1, 2, 3 |
| Theoretical classes | 26 | 1.04 | 1, 2, 3 |
| Type: Supervised | | | |
| Computer sessions | 12 | 0.48 | 1, 2, 3 |

| | | | |
|---|---|---|---|
| Type: Autonomous | | | |
| Personal study, problem solving and computer work | 90.5 | 3.62 | 1, 2, 3 |

## Assessment

In order to succeed this course, it is mandatory that the course grade C (weighted mean between the midterm exam and the final exam) is bigger than or equal to 4. It is also mandatory that the practical grade is bigger than or equal to 3.5.

The final grade F is computed as follows:

F = 0.2*P + 0.8*C,

where P is the practical grade.

In case someone takes the remedial examen, the final grade is computed as follows:

Set:

- R: remedial examen grade
- DC: definitive course grade

Then

DC = 0.3*C + 0.7*R,

and the final grade is given by

F = 0.2*P + 0.8*DC.

## Assessment Activities

| Title | Weighting | Hours | ECTS | Learning Outcomes |
|---|---|---|---|---|
| Final exam | 50 | 3 | 0.12 | 1, 2, 3 |
| Midterm exam | 30 | 2 | 0.08 | 1, 2, 3 |
| Practical exam | 20 | 2.5 | 0.1 | 1, 2, 3 |

## Bibliography

Borovkov, Konstantin. Elements of stochastic modelling. Second edition. World Scientific Publishing Co., 2014.

Dobrow, Robert P. Introduction to stochastic processes with R. John Wiley & Sons, 2016.

Rincón, Luis. Introducción a los procesos estocásticos. Las Prensas de Ciencias, Fac. de Ciencias, UNAM. It can be downloaded from: http://www.matematicas.unam.mx/lars/flip-procesos/flip-en-pdf/procesos2012.pdf

Pinsky, Mark A. and Karlin, Samuel. An introduction to stochastic modeling. Fourth edition. Elsevier/Academic Press, 2011.