UAB
Universitat Autònoma de Barcelona

Applied Stochastic Processes

Code: 42253
ECTS Credits: 6

2024/2025

Degree	Type	Year
4313136 Modelling for Science and Engineering	OT	0

Contact

Name: Vicente Mendez Lopez
Email: vicenc.mendez@uab.cat

Teachers

Vicente Mendez Lopez

Pedro Puig Casado

Alvaro Corral Cano

Daniel Campos Moreno

Teaching groups languages

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

Prerequisites

Calculus of several variables. Ordinary and partial differential equations. Introduction to probability theory

Objectives and Contextualisation

The main goal of this course is to provide powerfull tools to deal with the analysis and numerical simulations of stochastic processes both for systems affected by external noise of by internal noise. Applications to ecological and biological systems will be discussed in detail.

Competences

- Apply logical/mathematical thinking: the analytic process that involves moving from general principles to particular cases, and the synthetic process that derives a general rule from different examples.
- Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.
- Apply techniques for solving mathematical models and their real implementation problems.

- Conceive and design efficient solutions, applying computational techniques in order to solve mathematical models of complex systems.
- Formulate, analyse and validate mathematical models of practical problems in different fields.
- Isolate the main difficulty in a complex problem from other, less important issues.

Learning Outcomes

1. Apply logical/mathematical thinking: the analytic process that involves moving from general principles to particular cases, and the synthetic process that derives a general rule from different examples.
2. Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialisation.
3. Apply stochastic process techniques to predict the behaviour of certain phenomena.
4. Apply stochastic process techniques to study models associated with practical problems.
5. Identify real phenomena as models of stochastic processes and extract new information from this to interpret reality.
6. Implement the proposed solutions reliably and efficiently.
7. Isolate the main difficulty in a complex problem from other, less important issues.
8. Use specific software to model stochastic processes and, depending on the situation, estimate the corresponding parameters.

Content

First Part:

1. Elementary probability
2. Stochastic processes. Noise and Markov processes
3. Microscopic description: Stochastic differential equations and their integration. Applications to population dynamics

Second Part:

1. Mesoscopic description: Master equation. One-step processes. Diffusion approach. Biological and physical examples.
2. Random Walks. CTRW. Anomalous diffsuion, Lévy flights and First passage-time problems. Ecological and social applications

Third Part:

1. Discrete-time stochastic processes. Continuous state space models: AR, MA, ARMA and ARIMA. Parameter estimation, diagnostic tests and forecasting
2. Introduction to discrete state space models: INAR(1) and PoINAR(1).

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Classroom sessions	38	1.52	1, 2, 3, 4
Type: Supervised			
Mentoring	9	0.36	5, 6

Type: Autonomous			
Personal work	30	1.2	2, 3, 5
Preparation of assignments	20	0.8	1, 2, 4, 6, 8

The methodology of the course will combine traditional lectures in the classroom with autonomous activities by the student to practice the concepts seen in the course.

As a novelty, this year the first and the second part of the course (theory and practical applications) will be done intertwined to facilitate the assimilation of the contents.

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

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exam of the practical part	20%	1	0.04	1, 3, 4, 8
Exam of the theoretical part	25%	2	0.08	1, 2, 3, 4, 5, 6
Simulations and practical works	55%	50	2	1, 2, 3, 4, 5, 6, 7, 8

The avaluation will be divided into the three parts of the course:

First part. (33.3%)

There will be a problems assignment (10% of the final mark) and a general exam of this part (23.3%)

Second part. (35%)

There will be a short project to work with the concepts and techinques seen in the classroom (15% of the final mark) and a short exam of this part (18.3%).

Third part (30%)

There will be 2 or 3 assignments

Bibliography

Basic:

- V. Méndez, D. Campos, F. Bartumeus. Stochastic Foundations in Movement Ecology, Springer-Verlag, 2014

- C.W. Gardiner, ***Handbook of Stochastic Methods for Physics, Chemistry and the Natural Sciences***. Springer. Berlin. 1990
- L.J.S. Allen, ***An Introduction to Stochastic Processes with Applications to Biology***. Chapman & Hall/CRC, Boca Ratón. 2011
- R. Toral, P. Colet. ***Stochastic Numerical Methods***. Wiley-VCH, 2014

Complementary:

- N. van Kampen, ***Stochastic Processes in Physics and Chemistry***, Third Edition (North-Holland Personal Library) 2007
- J. Rudnick and G. Gaspari. ***Elements of the Random Walk***. Cambridge Univ. Press, 2004
- N.C. Petroni. ***Probability and Stochastic Processes for Physicists***. Springer-Verlag, 2020
- N. Lanchier. ***Stochastic Modelling***. Springer-Verlag, 2017

Software

The practical activities of the course will be carried out using Python and R languages

Language list

Name	Group	Language	Semester	Turn
(TEm) Theory (master)	1	English	first semester	afternoon