Universitat Autònoma de Barcelona

2021/2022

Applied Stochastic Processes

Code: 42253
ECTS Credits: 6

Degree	Type	Year	Semester
4313136 Modelling for Science and Engineering	OT	0	1

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

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Use of Languages

Principal working language: english (eng)

Teachers

Aureli Alabert

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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 examples.
2. Random Walks. CTRW. Anomalous diffsuion, Lévy flights and First passage-time problems. Ecological applications

Third Part:

1. Simulation of stochastic processes. Gillespie algorithm. Tau-leaping method. Reaction-diffusion methods. Next reaction method.

Methodology

Title	Hours	ECTS	Learning outcomes
Type: Directed			
Lectures 24	0.96		1,2,6,8
Practical cases 12	0.48		1,2,3,4,5,6,8
Simulation work 1 8	0.32		3,4,5,6,7
Type: Supervised			
Simulation work 2 8	0.32		3,4,5,6,7

Type Autonomous

Homework of lectures 5 0.2 1, 2,6, 8

Applied work 10 0.4 1,2,3,5,6

METHODOLOGY IN CASE OF TOTAL OR PARTIAL LOCKDOWN

The teaching methodology in case of lockdown will be adapted in order to get the normal progress of the course. Therefore, the lectures will become virtual and if the lockdown is partial there will be programmed tutorials. Along the virtual sessions the students will work the contents weekly established by the teacher. These contents will consist in theoretical lessons as well as practical problems to solve. To this end the students will may make use of the notes made by the teachers, books and problem sheets with solutions. All this material is available at the CV. The emerging doubts due to the students work will can be asked to the teachers according to the established schedule by using email or Discord. Furthermore, the teacher will program a virtual meeting with Teams if necessary. If the lockdown is partial there will be possible to solve the doubts in class.

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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Learning	35	1.4	1, 2, 4, 3
Type: Supervised			
Practice	62	2.48	5, 6

Assessment

Title	Weighting	Hours	ECTS	Learning outcomes

Exam 40% 4 0.16 1,2,3,5,6,8

Homework 10% 5 0.2 1,2,6,8

Simulation work 1 10% 7 0.28 3,4,5,6,7

Simulation work 2 10% 7 0.28 3,4,5,6,7

Applied work 30% 9 0.36 1,2,3,5,6

NOTE

In case of complete or partial face-to-face methodology the evaluation process will be the same as in the case of normal teaching.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exam of Theoretical concepts and skills	40%	3	0.12	1, 2, 4, 3, 5, 6
Simulations and practical works	60%	50	2	1, 2, 4, 3, 7, 5, 6, 8

Bibliography

- 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
- N. van Kampen, ***Stochastic Processes in Physics and Chemistry***, Third Edition (North-Holland Personal Library) 2007

Software

There are no specific programs