Universitat Autònoma de Barcelona

2017/2018

Applied Stochastic Processes

Code: 42253
ECTS Credits: 6

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

Contact

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Use of languages

Principal working language: english (eng)

Teachers

Alvaro Corral Cano

Tomas Alarcon

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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.

Skills

- 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 biological systems: population and epidemic 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

Activities

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

Evaluation

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

Evaluation activities

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