Deterministic Modelling

Code: 43479
ECTS Credits: 6

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

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Teachers

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Prerequisites

Students must have mathematical skills at a graduate level of a scientific degree.

Objectives and Contextualisation

The course aims to develop the students' ability to systematically analyze deterministic nonlinear dynamical models and to elaborate mathematical models of real systems.

Competences

- Analyse complex systems in different fields and determine the basic structures and parameters of their workings.
- Analyse, synthesise, organise and plan projects in the field of study.
- 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 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.
- Continue the learning process, to a large extent autonomously.

- 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.
- Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.
- Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
- Use appropriate numerical methods to solve specific problems.

Learning Outcomes

1. Analyse, synthesise, organise and plan projects in the field of study.
2. 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.
3. Choose the best description of a system on the basis of its particular characteristics
4. Construct and resolve models to describe the behaviour of a real system.
5. Continue the learning process, to a large extent autonomously.
6. Isolate the main difficulty in a complex problem from other, less important issues.
7. Solve and simulate models on the basis of numerical calculation methods and Monte Carlo methods.
8. Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.
9. Solve mathematical models by using analytic and numerical methods
10. Use acquired knowledge as a basis for originality in the application of ideas, often in a research context.
11. Use numerical calculation methods to solve complex problems.

Content

1.- Introduction to dynamical systems
Introduction.- Characteristic properties of nonlinear dynamical systems.- Examples of nonlinear dynamical behaviors.- Classification of dynamical systems.- Dynamical systems according to their dynamics.

2.- Discrete dynamical systems.
Maps.- Logistic map.- Fixed points. Stability.- Universality.

3.- Dynamical systems in one dimension.
Graphical Solution. Fixed-Points.- Analytical solution. Linear stability.- Numerical Solution.- Bifurcations.- Flows on the circle.- Synchronization of fireflies.

4.- Dynamical Systems in 2 dimensions. Oscillations.
Introduction. Dynamic Behaviors in 2 dimensions.- Linear stability.- Population dynamics.- Bifurcations.- Oscillations. Biological Rhythms.

5.- Dynamical Systems in 3 dimensions. Chaos.
Deterministic Chaos.- Lorenz Equations.- Rossler system.- Applications.- Chaos descriptors.- Epidemics.

6.- Introduction to numerical methods

Numerical integration of differential equations.- Methods and implementation.- Sources of error

7.- Spatio-temporal dynamics
Metapopulations.- Reaction-diffusion equation.- Linear diffusion.- Turing bifurcation.- Spatial patterning.- Diffusion-induced chaos.- Coupled map lattices.- Cellular automata.

Methodology

The methodology is based on lectures that include some exercises. Most exercises will be solved by the students and delivered periodically through the Virtual Campus. After that, any doubt about them will be discussed in class.

If the sanitary situation derived from Covid-19 required teaching to be virtual, our intention is to keep as much presenciality as possible, especially for exams. However, if necessary, teaching will be given by electronic means, either uploading the registered class so that you can visualize it at your convenience, or by sinchronous classes through some videoconference platform (Teams,...). In addition, some hours would be reserved weekly for tutorials via videoconference to solve doubts.

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			
Theory and exercise classes	38	1.52	2, 1, 4, 6, 5, 7, 9, 8, 3, 10, 11
Type: Supervised			
Assesments and projects	40	1.6	2, 1, 4, 6, 5, 7, 9, 8, 3, 10, 11
Type: Autonomous			
Personal study	69	2.76	2, 1, 4, 5, 7, 9, 8, 3, 11

Assessment

Grades will be obtained from:
1) deliveries of solved problems, simulations, reports and presentations.
2) at least two written exams, weighing around 50% of the final grade.

To pass the course:
- the average mark of the exams must be greater than 4 (on a scale of 10), and
- the final mark (exams and other evaluation tests) must be greater than 5.

Unique assessment

Students who have accepted the single assessment modality will have to take a final test which will consist of a written exam that will consist of problem solving and some theoretical questions. When you have finished, you will hand in all the exercise assignments and work reports.

The final grade is obtained in the same way as in the continuous assessment: the exam weighs around 50% of the final grade and the assignments the rest.

To pass the course, the exam grade must be greater than 4 (on a scale of 10), and the final average (exams and other assessment tests) must be greater than 5.

If the exam grade does not reach 4 or the final grade does not reach 5, the student has another chance to pass the subject by means of the resit exam. The same recovery system will be applied as for the continuous assessment: the part of the grade corresponding to theory and problems (around 50%) can be recovered, the part of deliveries cannot.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exams	around 50%	3	0.12	2, 4, 6, 9, 8
Projects and solved exercises	around 50%	0	0	2, 1, 4, 6, 5, 7, 9, 8, 3, 10, 11

Bibliography

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− W. A. Strauss, Partial Differential Equations: An Introduction, John Wiley & Sons, 1992.

− K. Kaneko. Theory and Applications of Coupled Map Lattices (Nonlinear Science: Theory and Applications) 1st Edition, 1993

− A. Ilachinski. Cellular Automata: A Discrete Universe, 2001

− U. Dieckmann, R. Law, J.A.J. Metz. The Geometry of Ecological Interactions: Simplifying Spatial Complexity: 1 (Cambridge Studies in Adaptive Dynamics, Series Number 1), 2000

Software

There is no specific software for the subject