Universidad Zaragoza

Academic Year/course: 2023/24

26933 - Chaos and Nonlinear Dynamic Systems

Syllabus Information

Academic year: 2023/24
Subject: 26933 - Chaos and Nonlinear Dynamic Systems
Faculty / School: 100 - Facultad de Ciencias
Degree: 447 - Degree in Physics
ECTS: 5.0
Year:
Semester: Second semester
Subject type: Optional
Module:

1. General information

The objective is to provide the student with the basic and computational tools necessary for the study of nonlinear dynamic systems . Its offer responds to an attempt to bring students closer to the study of problems that are usually outside the core curriculum, allowing them to approach the frontier of knowledge in the field of Statistical and Nonlinear Physics, a discipline of a transversal nature with implications in all areas of Science and Engineering.

The objectives are aligned with the following Sustainable Development Goals (SDGs):

- Goal 3: Health and wellness.
- Goal 11: Sustainable Cities and Communities
- Goal 15: Life of terrestrial ecosystems.

It is recommended to have taken Mathematical Analysis, Differential Equations and Computational Physics.

2. Learning results

The student, in order to pass this subject, must demonstrate the following results:

- Understands the uniqueness and importance of nonlinear dynamical systems.
- Is capable of analysing a nonlinear dynamic system.
- Knows the fundamental bifurcations of nonlinear dynamical systems.
- Understands and quantifies the phenomenon of chaos.
- Understands the basics of the synchronization phenomenon.
- Is able to develop dynamic models to analyse the compartmentalization of physical, social and biological systems. Recognizes and models nonlinear phenomena.

Upon completion of the subject the student will be able to:

- Analyse and understand nonlinear phenomena in various scientific fields.
- Master the tools of nonlinear science
- Develop and analyse nonlinear dynamic models.
- Understand paradigmatic phenomena in nonlinear science such as bifurcations, chaos and synchronization.
- Numerically simulate nonlinear dynamic systems.

3. Syllabus

Introduction

1) Low-dimensional dynamical systems:

1.1 Dynamical systems in one dimension. Flows in the line, bifurcations, flows in the circle.

1.2 Two-dimensional dynamic systems. Linear systems in the plane, phase portrait, limit cycles, bifurcations.

1.3 Chaos. Lorenz equations, one-dimensional maps, fractals, strange attractors.

2) High-dimensional dynamical systems:

2.1 Complex networks. Structural descriptors, dimension of a network, network generation models.

2.2 Stochastic processes. Network propagation phenomena, social contagion models, reaction-diffusion processes.

2.3 Nonlinear systems with many degrees of freedom. Synchronization in networks. Stability master function.

4. Academic activities

Learning activities

The teaching and evaluation activities will be carried out face-to-face. The program offers the students help to achieve the expected results and comprises the following activities:

- Participative lectures, including problems and simulations.
- Continuous evaluation sessions throughout the term consisting of short questionnaires to assess the degree of learning.
- Non-attendance simulations of nonlinear dynamic systems using specific software available to the student.
- Elaboration and presentation of a final group work in the context of the subject.

5. Assessment system

Continuous assessment:

It will consist of the following evaluation activities:

1. Short questionnaires on the different topics of the syllabus. There will be 5 quizzes which will have the same weight and, together, will contribute to 50% of the average grade (NP). The minimum grade to pass this evaluation must be 3.5 out of 10.

2. Writing and defence of a paper. The students will carry out (organized in groups) a work based on one of the projects proposed during the term. This activity contributes to 50% of the average grade (NP). The minimum grade to pass the activity must be 3.5 out of 10. In case of passing (NP>5), the final grade(NF) will be calculated from the following formula:

NF=5*[1+(NP-5)/(NPmax-5)]

(so if NP=5 then NF=5; if NP=NPmax then NF=10)

If NPmax<9 then NPmax=9 will be used.

Passing the subject by means of a single global test

This global test will consist of a written exam (50% of the final grade) and the evaluation of the work done and its public defence (50% of the final grade). Students who have already defended their work are exempted from presenting it in the single global test.