Complex Biological and Socio-economic Systems

Academic Year: (2022 / 2023) **Review date: 05-04-2022**

Department assigned to the subject: Mathematics Department

Coordinating teacher: SANCHEZ SANCHEZ, ANGEL

Type: Electives ECTS Credits : 3.0

Year : 1 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Computational and Applied Linear Algebra, Computational techniques for Differential Equations, Modeling and Nonlinear Analysis

OBJECTIVES

The main objective of the course is to provide students with basic knowledge of complexity sciences, both from the mathematical and applications point of view. In particular, it is intended that at the end of the course students will know basic aspects of complex systems, exemplified by percolation models; critical phenomena, presented as a paradigm of emergent properties; complex networks as a substrate to approach the analysis of complex systems, and propagation and diffusion processes in biological and socioeconomic systems, in the continuum and over networks.

With the work of the subject the student will acquire the following competences:

Basic Competences:

CB6: Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.

CB7: That students know how to apply acquired knowledge and problem-solving skills in new or unfamiliar environments within broader (or multidisciplinary) contexts related to the area of study.

CB9: That students know how to communicate their conclusions and the ultimate knowledge and rationale behind them to specialized and non-specialized audiences in a clear and unambiguous manner.

CB10: That students possess the learning skills that will enable them to continue studying in a way that will be largely self-directed or autonomous.

General Competences:

CG1: Collect and interpret data of a mathematical nature which can be applied to other domains of scientific knowledge.

CG2: Apply acquired knowledge and possess the ability to solve novel problems related with Mathematics.

CG5: Being able to communicate conclusions in clear and precise way.

CG6: Being able to autonomously study and do research.

Specific Competences:

CE3: Being able to abstract structural properties differentiating them from more accidental ones.

CE4: Being able to solve mathematical problems, planning their solution in terms of the available tools and of additional time and resource limitations.

CE7: Being able to model complex situations with deterministic and/or stochastic dependences.

CE8: Being able to reflect on obtained results, formulating their domain of validity and/or applicability.

CE9: Being able to perform mathematical modeling, as well as related computations and simulations, at technological and/or corporate engineering environments, in particular for research, development, and innovation tasks.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to complex systems: interactions, emergence
2. Complex networks: the scaffold of complex systems and models
3. Phase transitions and critical phenomena: the Ising model
4. Phase transitions and critical phenomena: percolation
5. Models for epidemic propagation
6. Complex social systems: non-strategic
7. Game theory and applications
8. Complex social systems: games on networks

LEARNING ACTIVITIES AND METHODOLOGY

LEARNING ACTIVITIES
Lectures
Tutoring
Group work
Individual assignments
Tests

METHODOLOGY
Lectures and online videos to acquire main concepts
Use of additional bibliography to deepen on specific concepts
Critical thinking activities related to the analysis of papers, videos and other material related with the course
Solving practical exercises (individually or in groups)
Discussion and presentation of assignments

ASSESSMENT SYSTEM

SE1 Participation in class - 10%
SE2 Individual or group assignments carried out during the course - 70%
+ Individual assignments - 40%
+ Group project - 30%
SE3 Final exam - 20%
+ Presentation and defense of a final assignment

% end-of-term-examination:	20
% of continuous assessment (assigments, laboratory, practicals…):	80

BASIC BIBLIOGRAPHY

- Alain Barrat, Marc Barthelemy, Alessandro Vespignani Dynamical Processes on Complex Networks, Cambridge University , 2012
- Herbert Gintis Game Theory Evolving: A Problem-Centered Introduction to Modeling Strategic Interaction, Second Edition, Princeton University Press, 2009
- Kim Christensen, Nicholas R. Moloney Complexity and Criticality, World Scientific, 2005