UNIVERSIDAD DE CASTILLA - LA MANCHA

GUÍA DOCENTE

1. General information

Course:	PHYSICS OF COMPLEX NETWORKS AND INTERDISCIPLINARY APPLICATIONS	**Code:**	310936
Type:	ELECTIVE	**ECTS credits:**	6
Degree:	2351 - MASTER DEGREE PROGRAMME IN PHYSICS AND MATHEMATICS-FISYMAT	**Academic year:**	2021-22
Center:	602 - E.T.S. INDUSTRIAL ENGINEERING OF C. REAL	**Group(s):**	20
Year:	1	**Duration:**	C2
Main language:	Spanish	**Second language:**	English
Use of additional languages:		**English Friendly:**	Y
Web site:		**Bilingual:**	N

Lecturer: **JUAN ANGEL ALEDO SANCHEZ** - Group(s): **20**

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Lecturer: **SILVIA MARTINEZ SANAHUJA** - Group(s): **20**

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2. Pre-Requisites

This course is self-contained so there is no need to have studied previously any contents related to this subject.

As a general enrollment requirement, the provisions of RD 1393/2007, as amended by RD 861/2010, were taken into account in order to define the entry requirements for the Master. Candidates must certify that they hold a bachelor's degree or equivalent in order to be eligible for admission to the master. International students from outside the EHEA must certify that they are qualified for admission to postgraduate courses.

Students admitted to this degree program are required to hold a bachelor's degree or equivalent in Mathematics or Physics. Other graduates with knowledge and skills of a level equivalent to holders of bachelor of engineering or science degrees are also eligible for admission to this master's degree.

3. Justification in the curriculum, relation to other subjects and to the profession

Nowadays, we can observe a clear tendency for interdisciplinary studies.The mathematical notions of complex networks have fruitful applications to other fields of knowledge. The understanding of reality through models based on networks is used, for example, in Engineering, Computation, Medicine, Biology, Ecology or Social Sciences. One of the aims of this course is to provide the basics that could be developped later depending on the interests of the students.

The topics of this course include: neural, biology, social and economic networks, useful in many branches of knowledge.

The course is also guided by the idea that students at this level must be able to become autonomous learners taking into account their future prospects to undertake research.

4. Degree competences achieved in this course

Course competences

Code	Description
CB06	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.
CB07	Apply the achieved knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to the area of study
CB08	Be able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of knowledge and judgments
CB09	Know how to communicate the conclusions and their supported knowledge and ultimate reasons to specialized and non-specialized audiences in a clear and unambiguous way
CB10	Have the learning skills which allow to continue studying in a self-directed or autonomous way
CE01	Solve physical and mathematical problems, planning their solutions based on the available tools and time and resource constraints
CE02	Develop the ability to decide the appropriate techniques to solve a specific problem with special emphasis on those problems associated with the Modeling in Science and Engineering, Astrophysics, Physics, and Mathematics
CE03	Have the ability to build and develop advanced mathematical reasoning, and delve into the different fields of mathematics
CE04	Have the ability to build and develop advanced physical reasoning, and delve into the various fields of physics and astrophysics

CE05	Know how to obtain and interpret physical and/or mathematical data that can be applied in other branches of knowledge
CE06	Prove the necessary capacity to perform a critical analysis, evaluation and synthesis of new and complex results and ideas in the field of astrophysics, physics, mathematics and biomathematics
CE07	Ability to understand and apply advanced knowledge of mathematics and numerical or computational methods to problems of biology, physics and astrophysics, as well as to build and develop mathematical models in science, biology and engineering
CE08	Ability to model, interpret and predict from experimental observations and numerical data
CG01	Know how to work in a multidisciplinary team and manage work time
CG02	Ability to generate and independently develop innovative and competitive proposals in research and professional activity in the scientific field of Physics and Mathematics
CG03	Present publicly the research results or technical reports, to communicate the conclusions to a specialized court, interested persons or organizations, and discuss with their members any aspect related to them
CG04	Know how to communicate with the academic and scientific community as a whole, with the company and with society in general about Physics and/or Mathematics and its academic, productive or social implications
CG05	Gain the ability to develop a scientific research work independently and in its entirety. Be able to search and assimilate scientific literature, formulate hypotheses, raise and develop problems and draw conclusions from the obtained results
CG06	Gain the capacity for dialogue and cooperation with scientific and business communities from other fields of research, including social and natural sciences
CT01	Promote the innovative, creative and enterprising spirit
CT02	Guarantee and promote respect for Human Rights and the principles of equality, universal accessibility, non-discrimination and democratic values and the culture of peace
CT03	Develop critical reasoning and the ability to criticize and self-criticize
CT04	Understand and reinforce the ethical and deontological responsibility and commitment in the performance of the professional and research activity and as a citizen
CT05	Autonomous learning and responsibility (analysis, synthesis, initiative and teamwork)

5. Objectives or Learning Outcomes

Course learning outcomes

Description

Understand the dynamics of complex networks generated by preferential attachment

Understand the underlying physics and emerging phenomena in complex neural networks

Understand the underlying physics and emerging phenomena in other complex networks such as trophic networks and metabolic networks

Understand the underlying physics and emerging phenomena in complex social networks. Understand the dynamics of the structure of social networks

Understanding of the concept of probability distribution of nodes and of correlations between nodes in complex networks

Understanding of the complex network concept in physics and mathematics, in particular the concept of random graph, scale invariant network, small world network and multiplex networks

Ability to simulate different types of complex networks by computer and to study their emerging properties

6. Units / Contents

Unit 1: Introduction to complex networks

Unit 2: Neural networks

Unit 3: Networks in systems biology. Boolean networks

Unit 4: Networks in ecology

Unit 5: Social and economic networks

7. Activities, Units/Modules and Methodology

Training Activity	Methodology	Related Competences (only degrees before RD 822/2021)	ECTS	Hours	As	Com	Description
Class Attendance (theory) [ON-SITE]	Combination of methods	CB06 CB07 CB09 CB10 CE01 CE02 CE05 CE07 CE08 CT03 CT05	1.48	37	Y	N	
Class Attendance (practical) [ON-SITE]	Combination of methods	CB06 CB07 CB09 CB10 CE01 CE02 CE05 CE07 CE08 CT03 CT05	0.16	4	Y	N	
Workshops or seminars [ON-SITE]	Workshops and Seminars	CE06 CG06	0.04	1	Y	N	
Writing of reports or projects [OFF-SITE]	Individual presentation of projects and reports	CB07 CB08 CB09 CB10 CG01 CG02 CG03 CG04 CG05 CT01 CT02 CT03 CT04 CT05	2.16	54	Y	Y	
Study and Exam Preparation [OFF-SITE]	Self-study	CB06 CB07 CB08 CB09 CB10 CE01 CE02 CE04 CE05 CE06 CE07 CG01 CG02 CG05 CT01 CT03 CT04 CT05	2.16	54	Y	N	
		Total:	**6**	**150**			
		Total credits of in-class work: 1.68					**Total class time hours: 42**
		Total credits of out of class work: 4.32					**Total hours of out of class work: 108**

As: Assessable training activity

Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

8. Evaluation criteria and Grading System

Evaluation System	Continuous assessment	Non-continuous evaluation*	Description
Assessment of problem solving and/or case studies	80.00%	80.00%	Students must solve individually some problems related with the contents of the course.
Theoretical papers assessment	10.00%	10.00%	Students must write individually a report about some topics of the course.
Other methods of assessment	10.00%	10.00%	Attendance and participation in the possible seminars of the course will be taken into account.
Total:	**100.00%**	**100.00%**	

According to art. 4 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 12.2) to be globally graded, in 2 annual calls per subject , an ordinary and an extraordinary one (evaluating 100% of the competences).

Evaluation criteria for the final exam:

Continuous assessment:

The final grade depends on the partial marks obtained from the exercises and other assignments (the deadlines will be published on Campus Virtual).

Non-continuous evaluation:

The final grade depends on the partial marks obtained from the exercises and other assignments (the deadlines will be published on Campus Virtual).

Specifications for the resit/retake exam:

Same conditions as before.

Specifications for the second resit / retake exam:

Same conditions as before.

9. Assignments, course calendar and important dates

Not related to the syllabus/contents

Hours	**hours**
Workshops or seminars [PRESENCIAL][Workshops and Seminars]	1

General comments about the planning: Teaching period may vary due to unexpected circumstances.

Unit 1 (de 5): Introduction to complex networks

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Combination of methods]	13
Class Attendance (practical) [PRESENCIAL][Combination of methods]	1
Writing of reports or projects [AUTÓNOMA][Individual presentation of projects and reports]	17
Study and Exam Preparation [AUTÓNOMA][Self-study]	17

Teaching period: Weeks 1-5

Unit 2 (de 5): Neural networks

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Combination of methods]	4
Writing of reports or projects [AUTÓNOMA][Individual presentation of projects and reports]	9
Study and Exam Preparation [AUTÓNOMA][Self-study]	9

Teaching period: Weeks 6-7

Unit 3 (de 5): Networks in systems biology. Boolean networks

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Combination of methods]	5
Class Attendance (practical) [PRESENCIAL][Combination of methods]	1
Writing of reports or projects [AUTÓNOMA][Individual presentation of projects and reports]	7
Study and Exam Preparation [AUTÓNOMA][Self-study]	7

Teaching period: Weeks 8-9

Unit 4 (de 5): Networks in ecology

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Combination of methods]	5
Class Attendance (practical) [PRESENCIAL][Combination of methods]	1
Writing of reports or projects [AUTÓNOMA][Individual presentation of projects and reports]	7
Study and Exam Preparation [AUTÓNOMA][Self-study]	7

Teaching period: Weeks 10-11

Unit 5 (de 5): Social and economic networks

Activities	**Hours**
Class Attendance (theory) [PRESENCIAL][Combination of methods]	10
Class Attendance (practical) [PRESENCIAL][Combination of methods]	1
Writing of reports or projects [AUTÓNOMA][Individual presentation of projects and reports]	14
Study and Exam Preparation [AUTÓNOMA][Self-study]	14

Teaching period: Weeks 12-15

Global activity

Activities	**hours**
Workshops or seminars [PRESENCIAL][Workshops and Seminars]	1
Writing of reports or projects [AUTÓNOMA][Individual presentation of projects and reports]	54
Study and Exam Preparation [AUTÓNOMA][Self-study]	54
Class Attendance (practical) [PRESENCIAL][Combination of methods]	4
Class Attendance (theory) [PRESENCIAL][Combination of methods]	37
Total horas:	150

10. Bibliography and Sources

Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
Ricardo Vicente Solé, Susanna C. Manrubia	Orden y caos en sistemas complejos, Volumen 2	Univ. Politèc. de Catalunya		84-8301-431-9	2009	
Juan A. Aledo, S. Martínez and Jose C. Valverde	Parallel Dynamical Systems over Graphs and related topics: A survey http://dx.doi.org/10.1155/2015/594294				2015	
R. Rodeva	Algebraic and Discrete Mathematical Methods for Modern Biology	Academic Press			2015	
E. Bujalance y otros	Elementos de matemática discreta	Sanz y Torres		84-96094-61-8	2005	
J.A. Aledo, J. Penabad, J.C. Valverde y J.J. Villaverde	Ejercicios de Álgebra y Matemática Discreta I	Alpeviva			2001	
J.A. Aledo, J. Penabad, J.C. Valverde y J.J. Villaverde	Álgebra y Matemática Discreta	Alpeviva			2002	
Jordán Lluch, Cristina	Introducción a la teoría de grafos y sus algoritmos	Reverté Universidad Politécnica de Valencia		84-7721-438-7	1996	
K. Erciyes	Complex networks. An algorithmic perspective	CRC Press		978-1-4665-7167-9	2015	