UNIVERSITAT POLITÈCNICA
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BARCELONATECH

Course guide
480171 - XCSE - Complex and Socio-Environmental Networks

Last modified: 12/06/2023

Unit in charge:	Barcelona School of Civil Engineering
Teaching unit:	724 - MMT - Department of Heat Engines.

Degree: MASTER'S DEGREE IN SUSTAINABILITY SCIENCE AND TECHNOLOGY (Syllabus 2013). (Optional subject).

Academic year: 2023   **ECTS Credits:** 5.0   **Languages:** English

LECTURER

Coordinating lecturer: MARTI ROSAS CASALS

Others:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. The ability to design, develop, apply and assess conceptual frameworks, methods and techniques for modelling, simulating and assessing socio-environmental systems using complex networks, intelligent decision-making support systems and continuous models, for the promotion of sustainable development and sustainability.

Transversal:
2. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

The following teaching methods will be used in the development of the course:

Lecture or conference (EXP): Sharing knowledge through lectures by professors or by external guest speakers.
Problem solving and case studies (RP): group decision exercises, debates and group dynamics, with the teacher and students in the classroom; class presentation of an activity carried out individually or in small groups.
Carry out a project, activity or work of reduced scope (PR): to carry out, individually or in a group, of a homework assignment of reduced complexity or scope, applying knowledge and presenting results.
Evaluation Activities (EV).

Training activites:

The following training activities will be used in the development of the course:

Face-to-face
Theoretical classes and conferences (CTC): knowledge, understanding and synthesis of contents presented by the lecturer (professor) or by guest speakers.
Practical classes (CP): participation in group exercises, as well as discussions and group dynamics, with the teacher and other students in the classroom.
Presentations (PS): class presentations of an activity carried out individually or in small groups.
Theoretical/practical work tutorials (TD): carry out in the class an activity or exercise, theoretical or practical in nature, individually or in small groups, with the advice of the professor.

Remote
Carry out a project, activity or work of reduced scope (PR): to carry out, individually or in a group, of a homework assignment of reduced complexity or scope, applying knowledge and presenting results.
Autonomous study (EA): study or development of the subject individually or in groups, understanding, assimilating, analysing and synthesising knowledge.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, each student should be able to:

Understand the structure and evolution of networks, drawing on knowledge from disciplines as diverse as sociology, ecology, mathematics, computer science, economics and physics.

Apply analytical tools to characterize the structure of social and ecological networks as well as to modelling their dynamic behaviour and interactions.

STUDY LOAD

Type	Hours	Percentage
Hours small group	9,0	7.20
Self study	80,0	64.00
Hours large group	24,0	19.20
Hours medium group	12,0	9.60

Total learning time: 125 h

CONTENTS

1. Complexity and networks

Description:
Present network science as a useful tool for studying the characteristics of complex systems. Why is their study important and what implications have they had for the field of sustainability. Introduction to the different types of networks that can be found in the real world, including technological, social and biological networks, and the empirical techniques used to discover their structure.

Specific objectives:
(a) Define and present what is meant by a network.
(b) Understand its importance when studying complex systems and, in particular, the interactions between the actors that make up these systems.
(c) Present the type of data needed and how it can be obtained to recreate the structure of a network.
(d) Introduce some of the softwares that allow the visualization and study of networks.

Related activities:
A1

Full-or-part-time: 24h 30m
Theory classes: 7h
Self study : 17h 30m

2. Fundamentals of network theory

Description:
It introduces the fundamental theoretical ideas on which the current state of network science is based.

Specific objectives:
(a) Present the basic mathematics for the study of networks.
(b) Present measures and metrics used to quantify their structure and the patterns that emerge when applying these measures to real networks.

Related activities:
A2

Full-or-part-time: 36h 45m
Theory classes: 10h 30m
Self study : 26h 15m

3. Introduction to computational algorithms

Description:
The measures presented in Unit 2 are, most of the time, only possible through the use of computers and their consequent computational algorithms. Some of the most important algorithms are introduced here.

Specific objectives:
(a) Recognize the need for programming for everyone who wants to work with networks.
(b) Present the basic instructions to generate these algorithms at the computational level.

Full-or-part-time: 12h 15m
Theory classes: 3h 30m
Self study : 8h 45m

4. Network models and aplications

Description:
Introduction to mathematical models of networks. The classic network models are presented (i.e., random graph) as well as the new models that have emerged in recent years (i.e., scale-free, small-world, etc.)

Specific objectives:
(a) Present the fundamental network models.
(b) Recognize its theoretical and mathematical foundations.

Related activities:
A3

Full-or-part-time: 36h 45m
Theory classes: 10h 30m
Self study : 26h 15m

5. Dynamic processes on networks

Description:
Some dynamic processes that occur in networks such as cascading failures, resilience, epidemiology and contagion are presented. The questions currently being asked by the scientific community and the potential of network science to answer them are presented.

Specific objectives:
(a) Present the classic dynamic processes that occur in networks, with special emphasis on the processes of resilience and contagion.
(b) Recognize the potential of network science to help analyze and perhaps solve problems associated with the sustainability paradigm.

Full-or-part-time: 14h 45m
Theory classes: 3h 30m
Guided activities: 2h 30m
Self study : 8h 45m

ACTIVITIES

A1. SELECTion of A NETWORK AND VISUALIZation

Description:
Select a real network, which will be studied further on, and visualize it with some computer application.
Groups of 4-5 people are asked to select a real network to be studied later on, and visualize it in a software application.

Specific objectives:
(a) Be familiar with a computer program aimed at visualizing and analysing networks.
(b) Recognize the many difficulties related with the data needed to reproduce the structure of a network of any kind.

Material:
Pajek (http://pajek.imfm.si/doku.php)
NodeXL (http://nodexl.codeplex.com/)
Gephi (https://gephi.org/)

Delivery:
List of nodes and edges in a spreadsheet.
First image of the network visualized in JPG, PNG, TIFF, etc.

Full-or-part-time: 5h
Self study: 5h

A2. Analysis and centrality measures in networks

Description:
Groups of 4-5 people are asked to use the network from activity A1 to quantify its structure and obtain statistical data on its topology, to be compared later with other network examples from other groups.

Specific objectives:
(a) Apply the concepts presented in classroom to determine the structure of a network.
(b) Discuss and try to understand the reason for the differences observed between the networks of the different groups.

Material:
Same as in A1
Guiding questions

Delivery:
Answer to the guiding questions in PDF.

Full-or-part-time: 10h
Self study: 10h

A3. Results, discussion and paper presentation

Description:
It is requested that, in groups of 4-5 people, a report be written in the format of a scientific article where the results and their discussion are presented, in order to be evaluated by the other participants of the course in depth and form, and both in its written format and in its oral presentation.

Specific objectives:
(a) Develop the capacity for synthesis and scientific criticism.
(b) Introduce the participant to the formal conditions of writing a scientific article.

Material:
Guide for writing scientific articles

Delivery:
Scientific article in PDF

Full-or-part-time: 15h 50m
Guided activities: 2h 30m
Self study: 13h 20m

GRADING SYSTEM

EV1: Written test (PE). 30%
EV2: Individual or group coursework (TR). 70%

BIBLIOGRAPHY

Basic:
- Newman, M.E.J. Networks. Oxford: Oxford University Press, 2018. ISBN 0198805098.
- Solé, R. Redes complejas: del genoma a internet. Barcelona: Tusquets, 2009. ISBN 9788483831175.

Complementary:
- Watts, D.J. Seis grados de separación: la ciencia de las redes en la era del acceso. Barcelona: Paidós, 2006. ISBN 844931772X.
- Barabási, A.L. Linked : the new science of networks. Cambridge: Perseus, 2002. ISBN 0738206679.