

## Syllabus

### Subject

|                                |  |
|--------------------------------|--|
| <b>Subject / Group</b>         | 11003 - Complex Networks / 1           |
| <b>Degree</b>                  | Master's in Physics of Complex Systems |
| <b>Credits</b>                 | 3                                      |
| <b>Period</b>                  | 1st semester                           |
| <b>Language of instruction</b> | English                                |

### Professors

| Lecturers               | Office hours for students |                |           |            |            |   |
|-------------------------|---------------------------|----------------|-----------|------------|------------|---|
|                         | Starting time             | Finishing time | Day       | Start date | End date   | Office / Building   |
| Victor Martinez Eguiluz | 12:00                     | 13:00          | Thursday  | 21/10/2019 | 24/01/2020 | 201 Ed. Institutos Universitarios                         |
|                         | 16:00                     | 18:00          | Wednesday | 16/10/2019 | 31/03/2020 | Office 104 A / Edifici Instituts Universitaris de Recerca |
| Sandro Meloni           |                           |                |           |            |            |   |

### Context

This is one of the compulsory courses of the Structural Module of the Master of Physics of Complex Systems. The aim of this subject is to introduce the recent developments of the so-called Theory of Complex Networks.

### Requirements

#### Recommended

It is highly recommended that students have taken statistical physics courses during their undergraduate studies and have at least basic knowledge of computational methods.

### Skills

#### Specific

- \* E2: To develop and apply optimally numerical algorithms for the simulation of complex systems
- \* E15: To understand the main concepts and techniques of complex networks

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### Generic

- \* TG2: To acquire the capability to develop a complete research project: bibliographic search, subject development and elaboration of conclusions
- \* TG3: To be able to write in a clear, precise and rigorous way the different steps of the research process and to present the results to an expert audience
- \* TG6: To acquire high computational skills and advanced numerical methods capabilities in applications to problems in the context of complex systems

### Basic

- \* You may consult the basic competencies students will have to achieve by the end of the Master's degree at the following address: [http://estudis.uib.cat/master/comp\\_basiques/](http://estudis.uib.cat/master/comp_basiques/)

## Content

### Range of topics

1. Introduction
  - History of complex networks. Sociology and Mathematics.
  - Examples of networks. Biological, social, technological networks.
  - Random networks. The Erdős-Rényi model.
  - Regular Networks.
2. Small-world networks
  - Diameter and clustering. Empirical evidence.
  - Watts-Strogatz model.
3. Scale-free networks.
  - Distribution of degree. Empirical evidence.
  - Barabasi-Albert model.
  - Configurational model.
4. Characterization of networks.
  - Correlations of degree. Assortativity. Betweenness.
  - Communities. Detection of communities.
  - Motifs.
  - Directed networks; weighted nets.
5. Dynamics on complex networks.
  - Random walks.
  - Percolation and fault tolerance.
  - Epidemic spreading.
  - Synchronization.
6. Advanced complex networks
  - Multilayer networks
  - Temporal networks
7. Computational modeling of complex Networks
  - Introduction to Python's NetworkX
  - Visualization with Gephi, cytoscape

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### Teaching methodology

In-class work activities (0.75 credits, 18.75 hours)

| Modality       | Name     | Typ. Grp.       | Description   | Hours |
|----------------|----------|-----------------|---|-------|
| Theory classes | Lectures | Large group (G) | The students will acquire the concepts and methodology to understand state-of-the-art research in complex networks. | 18.75 |

At the beginning of the semester a schedule of the subject will be made available to students through the UIBdigital platform. The schedule shall at least include the dates when the continuing assessment tests will be conducted and the hand-in dates for the assignments. In addition, the lecturer shall inform students as to whether the subject work plan will be carried out through the schedule or through another way included in the Aula Digital platform.

Distance education tasks (2.25 credits, 56.25 hours)

| Modality              | Name                            | Description   | Hours |
|-----------------------|---------------------------------|---|-------|
| Individual self-study | Assignments & oral presentation | <p>The students will apply the concepts and techniques learnt during the lectures to solve assignments.</p> <p>The students will also present the final project as a short oral presentation and as a written report.</p> | 56.25 |

### Specific risks and protective measures

The learning activities of this course do not entail specific health or safety risks for the students and therefore no special protective measures are needed.

### Student learning assessment

#### Frau en elements d'avaluació

In accordance with article 33 of Regulation of academic studies, "regardless of the disciplinary procedure that may be followed against the offending student, the demonstrably fraudulent performance of any of the evaluation elements included in the teaching guides of the subjects will lead, at the discretion of the teacher, a undervaluation in the qualification that may involve the qualification of "suspense 0" in the annual evaluation of the subject".

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### Lectures

|                     |   |
|---------------------|---|
| Modality            | Theory classes  |
| Technique           | Papers and projects ( <b>non-retrievable</b> )  |
| Description         | The students will acquire the concepts and methodology to understand state-of-the-art research in complex networks. |
| Assessment criteria | Participation in the lectures.<br><br>Accuracy and quality of the presented work.                                   |

Final grade percentage: 50%

### Assignments & oral presentation

|                     |   |
|---------------------|---|
| Modality            | Individual self-study   |
| Technique           | Papers and projects ( <b>non-retrievable</b> )  |
| Description         | The students will apply the concepts and techniques learnt during the lectures to solve assignments. The students will also present the final project as a short oral presentation and as a written report. |
| Assessment criteria | Presentation (both oral and written) and quality of the project proposed by the lecturer.   |

Final grade percentage: 50%

### Resources, bibliography and additional documentation

#### Basic bibliography

A.-L. Barabási, Network Science (Cambridge University Press, 2016) <http://networksciencebook.com/>  
M.E.J. Newman, Networks: An Introduction (Oxford University Press, 2010).  
S Fortunato, Community detection in graphs, Physics Reports 486, 75-174 (2010).  
S. Boccaletti et al, Complex networks: structure and dynamics, Phys. Rep. 424, 175-308 (2006).  
M.E.J. Newman, The structure and function of complex networks, SIAM Rev. 45, 167-256 (2003).  
V. Nicosia, V. Latora, G. Russo, Complex Networks, CUP (2017) <https://doi.org/10.1017/9781316216002>  
A. Barrat, M. Barthélemy, A. Vespignani, dynamical Processes on complex Networks. CUP (2012). <https://doi.org/10.1017/CBO9780511791383>

