Course guides
230850 - CPC - Critical Phenomena and Complexity

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 748 - FIS - Department of Physics.
Degree: MASTER'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2018). (Compulsory subject).
Academic year: 2021 ECTS Credits: 5.0 Languages: Catalan, Spanish, English

LECTURER

Coordinating lecturer: Ramirez De La Piscina Millan, Laureano
Others: Pastor Satorras, Romualdo

TEACHING METHODOLOGY

Classroom sessions will be devoted to a careful presentation of the basic concepts and main results which will be illustrated with some examples. With some periodicity students present exercises or topics which have previously been proposed.

LEARNING OBJECTIVES OF THE SUBJECT

Becoming familiar with phenomenology and analytical techniques of critical phenomena.
Knowing and being able to apply to physical systems the techniques of bifurcation theory analysis.
Becoming familiar with the modeling of multidisciplinary systems with stochastic behavior.
Being able to apply stochastic process techniques to simple systems.
Becoming familiar with complex network systems, and be able to characterize them.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>48,0</td>
<td>37.21</td>
</tr>
<tr>
<td>Self study</td>
<td>81,0</td>
<td>62.79</td>
</tr>
</tbody>
</table>

Total learning time: 129 h
## CONTENTS

### Dynamical systems

**Description:**
- Flows and Maps
- Bifurcations
- Normal Form
- Conservative systems.
- Local and global bifurcations
- Chaos
- Pattern formation

**Full-or-part-time:** 31h 15m  
- Theory classes: 10h  
- Guided activities: 6h 15m  
- Self study: 15h

### Stochastic Processes

**Description:**
- Introduction to stochastic processes.  
- Markov Process  
- Stochastic differential equations  
- First passage and relaxation times  
- Spacially distributed systems

**Full-or-part-time:** 31h 15m  
- Theory classes: 10h  
- Guided activities: 6h 15m  
- Self study: 15h

### Non-equilibrium critical phenomena

**Description:**
- Introduction to equilibrium critical phenomena  
- Non-equilibrium systems  
- Percolation  
- Absorbing-state phase transitions  
- Other examples of non-equilibrium systems

**Full-or-part-time:** 31h 15m  
- Theory classes: 10h  
- Guided activities: 6h 15m  
- Self study: 15h
Complex networks

Description:
Introduction to complex networks
The large-scale structure of complex networks
Dynamical processes on complex networks
Network models

Full-or-part-time: 31h 15m
Theory classes: 10h
Guided activities: 6h 15m
Self study: 15h

GRADING SYSTEM

Marks will be obtained from written questionnaires and exercises (PE),
and classroom presentations and participation (TC).
The final score will follow from: 0.70*PE+0.30*TC

BIBLIOGRAPHY

Basic: