Course guide
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: 2022  ECTS Credits: 5.0  Languages: Catalan, Spanish, English

LECTURER

Coordinating lecturer: Consultar aquí / See here:
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here:
https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

PRIOR SKILLS
- Differential equations
- Fundamentals of Probability and Statistics
- Fundamentals of Statistical Mechanics can be useful, but not compulsory

REQUIREMENTS
None

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Basic:
CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.

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>
</tr>
</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

**Specific objectives:**
Become familiar with the Dynamic Systems tools for the analysis of complex systems

**Related activities:**
Presentation of written exercises

**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

**Specific objectives:**
Familiarize with the techniques of stochastic processes for the analysis of the dynamics of different systems

**Related activities:**
Presentation of written exercises

**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

Specific objectives:
Familiarize with different critical non-equilibrium phenomena and their analysis

Related activities:
Presentation of written exercises

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

Specific objectives:
Becoming familiar with complex network systems, and be able to characterize them.

Related activities:
Presentation of written exercises

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

GRADING SYSTEM

Marks will be obtained from written exercises (PE), and classroom presentations and participation (TC).
The final score will follow from: 0.70*PE + 0.30*TC
There are no reassessable evaluation acts.

EXAMINATION RULES.

It does not apply
BIBLIOGRAPHY

Basic:

RESOURCES

Other resources:
UPC Virtual Campus, Atenea