Course guide
230850 - CPC - Critical Phenomena and Complexity

Last modified: 14/12/2023

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: 2023 **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. Students should know how to apply the knowledge acquired and their problem-solving ability in new or little-known environments within broader (or multidisciplinary) contexts related to their area of ¿¿study.

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

Type	Hours	Percentage
Hours large group	48,0	37.21
Self study	81,0	62.79

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:
- Livi, R.; Politi, P. Nonequilibrium Statistical Physics: A Modern Perspective. Cambridge: Cambridge University Press, 2017. ISBN 9781107049543.
- Menczer, F.; Fortunato, S.; Davis, C.A. A first course in network science. Cambridge University Press, 2020. ISBN 9781108471138.
- Stauffer, D.; Aharony, A. Introduction to percolation theory. Rev. 2nd ed. London ; New York: Taylor & Francis, 1994. ISBN 0748402535.
- Strogatz, S.H. Nonlinear dynamics and chaos: with applications to physics, biology, chemistry and engineering [on line]. 2nd ed. Cambridge: CRC Press Press, 2015 [Consultation: 21/09/2020]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=1181622. ISBN 9780813349107.
- Gardiner, C.W. Stochastic methods: a handbook for the natural and social sciences. 4th ed. Berlin: Springer-Verlag, 2009. ISBN 9783540707127.

RESOURCES

Other resources:
UPC Virtual Campus, Atenea