UCLouvain

lphys2114

2024

Nonlinear dynamics

5.00 credits	22.5 h + 22.5 h	Q1

Teacher(s)	Crucifix Michel ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	LMAT1122 and LMAT1261 for the studentsenrolled in the Bachelor in physicswho wish to follow this teaching unitwithin theadditional module in physics.
Main themes	This teaching unit is an introduction to the concepts and methods of the theory of dynamical systems as well as its application to physics, chemistry, biology and engineering.
Learning outcomes	**At the end of this learning unit, the student is able to :** **a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2MA)** 1.1, 1.3, 1.4, 2.1, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 **b. Specific learning outcomes of the teaching unit** 1 At the end of this teaching unit, the student will be able to : 1. use mathematical tools to characterise the properties of discrete and continuous non-linear systems; 2. characterise the chaotic dynamics of a system.
Evaluation methods	The evaluation is based on a written exam and a continuous assessment during the semester. The written exam deals with the application of the theory of non-linear systems to concrete examples. It tests the student's knowledge and his understanding of the notions seen in the theoretical course, the mastery of calculation techniques and the coherent presentation of this analysis. The result of the continuous (4 points out of 20) assessment will be used for each session and cannot be represented. The septembre exam, when it is presented, is oral with written preparation.
Teaching methods	The learning activities consist of lectures and exercise sessions. The lectures introduce fundamental concepts of the theory of nonlinear systems and their motivation through concrete examples from various scientific disciplines. The main objective of the exercise sessions is the application of the theory to concrete examples.
Content	The teaching unitprovides the student with an introduction to the mathematical theory of dynamical systems and its applications to problems of physics, chemistry, biology and engineering. The following topics are covered by the teaching unit: 1. **Basic concepts:** definition of a dynamical system, examples of continuous and discrete dynamic systems, hyperbolic points of equilibrium and stability, bifurcations (with examples from physics) 2. **Lineari s ation , stable and unstable manifolds :** the dynamics of linear systems, classification of two-dimensional fixed points, linearisation around hyperbolic fixed points, stable and unstable manifolds, perturbative analysis; 3. **The Poincaré-Bendixon theorem:** trapping regions, limit cycles and limit sets, the Poincaré map, the Poincaré-Bendixon theorem, applications (existence of periodic orbits, Liénard systems). 4. **Periodic orbits**, with a hint at phenomena of resonance 5. **Discrete systems:** basic concepts, chaos and sensitivity to initial conditions, itineraries, topological conjugation, Lyapunov exponents, the logistic map.
Inline resources	The MoodleUCL website of this teaching unit contains a detailed plan of the covered topics, a complete bibliography, exercise sheets and a collection of exam subjects from past years.

Bibliography	The main and only compulsary reference is available online. Additional references used to prepare the lecture include # S.H. Strogatz, Nonlinear dynamics and chaos. Westview Press 1 7 (2015). # S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos, Springer (2003) # R. Hilborn, Chaos and Nonlinear Dynamics: An Introduction for Scientists and Engineers (2nd edn) , Oxford University Press (2000) # H. Dijkstra, Nonlinear Physical Oceanography, A Dynamical Systems Approach to the Large Scale Ocean Circulation and El Ni˜no, Springer Science+Business Media (2000) # Alligood K., T. Sauer and J. Yorke (1997), Chaos: An Introduction to Dynamical Systems, Springer (NewYork) # Perko L. (2001), Differential Equations and Dynamical Systems, Springer, ISBN 978-1-4612-6526-9 •
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Additionnal module in Mathematics	APPMATH	5		
Additionnal module in Physics	APPHYS	5		
Master [60] in Physics	PHYS2M1	5		
Master [120] in Mathematics	MATH2M	5		
Master [120] in Physics	PHYS2M	5		