UCLouvain

lphys2114

2020

Nonlinear dynamics

Due to the COVID-19 crisis, the information below is subject to change, in particular that concerning the teaching mode (presential, distance or in a comodal or hybrid format).

5 credits	22.5 h + 22.5 h	Q1

Teacher(s)	Hagendorf Christian ;
Language :	English
Place of the course	Louvain-la-Neuve
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.
Aims	1 **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** 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. - - - - *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled "Programmes/courses offering this Teaching Unit".*
Evaluation methods	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** 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 assessment will be used for each session and cannot be represented. The evaluation methods may be adapted and modified according to the evolution of the Covid-19 pandemic.
Teaching methods	**Due to the COVID-19 crisis, the information in this section is particularly likely to change.** 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. 2. **Discrete chaotic systems:** chaos and sensitivity to initial conditions, itineraries, topological conjugation, Lyapunov exponents, the logistic map. 3. **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; 4. **The horseshoe map :** intersections of stable and unstable manifolds, homoclinic points, horseshoe and chaos, Cantor sets; 5. **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). 6. **E rgodic theory:** the concept of ergodicity, relations with statistical mechanics, Poincaré's reccurrence theorem, ergodic theorems, examples and applications.
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	• K.T. Alligood, T.D. Sauer, J.A. Yorke, Chaos. An introduction to dynamical systems. Springer-Verlag (2008). • M.W. Hirsch, S. Smale, R.L. Devaney, Differential equations, dynamical systems, and an introduction to chaos. Academic Press (2013). • S.H. Strogatz, Nonlinear dynamics and chaos. Westview Press (2015). • M. Tabor, Chaos and integrability in non-linear dynamics : an introduction. J. Wiley & Sons (1989).
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)

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