





5 credits

22.5 h + 22.5 h

Q1

Teacher(s)	Hagendorf Christian ;
Language :	French
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	<p>a. Contribution of the teaching unit to the learning outcomes of the programme (PHYS2MA)</p> <p>1.1, 1.3, 1.4, 2.1, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6</p> <p>b. Specific learning outcomes of the teaching unit</p> <p>1</p> <p>At the end of this teaching unit, the student will be able to :</p> <ol style="list-style-type: none"> 1. use mathematical tools to characterise the properties of discrete and continuous non-linear systems; 2. characterise the chaotic dynamics of a system. <p>-----</p> <p><i>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".</i></p>
Evaluation methods	The evaluation is based on a written exam. It 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.
Teaching methods	The learning activities consist of lectures, exercise sessions and a personal project. 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 unit provides 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: <ol style="list-style-type: none"> 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. Linearisation, 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. Ergodic theory: the concept of ergodicity, relations with statistical mechanics, Poincaré's recurrence 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	<ul style="list-style-type: none"> • 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 [120] in Physics	PHYS2M	5		
Master [120] in Statistic: General	STAT2M	5		
Additional module in Physics	LPHYS100P	5		
Additional module in Mathematics	LMATH100P	5		