LUND UNIVERSITY

Faculty of Science

FYST57, Physics: Chaos for Science and Technology, 7.5 credits

Fysik: Kaos för naturvetenskap och teknik, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2021-12-10 to be valid from 2021-12-10, autumn semester 2022.

General Information

The course is an elective second cycle component of a Bachelor or Master of Science degree in Physics.

Language of instruction: English

Main field of studies	*Depth of study relative to the degree requirements*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Learning outcomes

The aim of the course is to introduce chaotic systems and different approaches towards non-linear problems. Several conceptual tools and examples to approach and interpret the non-linear are provided to the student in order to understand complex systems and their eventually chaotic nature. The course shows the pervasive nature of these concepts and gives a possibility to reflect over the fascinating phenomena which may show up in chaotic systems. The abstract and theoretical nature of chaos theory is declined in practical and concrete concepts. For example, strange attractors will highlight the importance of fractal geometry, in order to discuss the posibility that the Solar system is unstable over a longer time scale. The fascinating universality of chaotic behaviour across science and technology will deliver a precious lesson on the beauty and impact of mathematical investigation of phenomena.

Knowledge and understanding
On completion of the course, the students shall be able to:

- decribe the system conditions leading to chaotic and regular behaviour, respectively.
- account for and interpret mathematical methods used to analyse chaotic systems
- describe why it is useful to introduce dimensions which are not integer.

Competence and skills
On completion of the course, the students shall be able to:

- apply mathematical methods used for the description of non-linear systems
- analyse the time development of a system and be able to determine if the system is chaotic or regular
- determine which mathematical models are appropriate in different situations
- determine the dimension of simple fractals.

Judgement and approach
On completion of the course, the students shall be able to:

- demonstrate an understanding of possibilities and limitations of methods that are covered in the course.
- find properties of the phase space of simple non-linear problems and discuss the chaotic nature of such systems.
- demonstrate a methodology to approach the study of complex problems in the project setting.
- interpret and assess information in the field of the course from sources in addition to the course material, e.g. scientific articles and advanced literature.

Course content

The course gives an introduction to non-linear and chaotic systems, i.e. non-linear systems that are deterministic but with a time development which is not predictable over longer periods. The study of non-linear systems is an application of mathematics with profound impact on our understanding of physical, biological, computer, and complex systems in general. The course will introduce the mathematical methods needed to study discrete and continuous non-linear systems. Then, it will provide examples of non-linear systems in science and technology.

Temporally discrete systems.

- Feigenbaum’s theory of branching
- Dependence on initial values
- Fractal geometry with various applications
- Different definitons of dimensions
- Cellular Automata

Continuous systems

- Systems of differential equations
- Phase space and the Poincaré section
- Lyapunov exponents and strange attractors
- Coupled oscillators and frequency locking

- Dissipative systems.
- After the basic discrete and continuous representations, students must choose an additional study module. Different study modules can be offered according to need and availability, including the application of chaos theory in physics, or biology, economics. One of this study modules is always offered.

Conservative systems and the KAM theory

- Hamilton's formalism
- Integrable systems, billiards
- Area-preserving maps
- Chaotic motion in the Solar system.

Course design

The teaching consists of lectures, group work with a course project. Participation in the introduction lesson to group work, and project report are compulsory.

Assessment

Examination takes place through a written examination at the end of the course, and the written report of the group project. For students who have not passed the regular examination, an additional examination during timetabled retake period is offered.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Subcourses that are part of this course can be found in an appendix at the end of this document.

Grades

Marking scale: Fail, Pass, Pass with distinction.
For a grade of Pass on the whole course, the student must have passed the written examination and the project.

The grade for the written exam is Fail, Pass, Pass with distinction. The grading scale for the project is Fail, Pass.

The final grade is determined by the grade on the written examination.

Entry requirements

To be admitted to the course, students must have 75 credits in science studies and 45 credits in mathematics, including knowledge corresponding to MATB21 Multivariate Analysis 1, 7.5 credits and English 6/B.

Further information

The course cannot be included in a degree together with FYST13, Physics: Chaos for Science and Technology, 7.5 credits.

The course is to be studied together with FMFN05, Chaos, 7.5 credits, which is coordinated by LTH.

The written exam is scheduled according to exam schedule of LTH.

Subcourses in FYST57, Physics: Chaos for Science and Technology

Applies from H22

2201 Exam, 6,0 hp
Grading scale: Fail, Pass, Pass with distinction
2202 Project, 1,5 hp
Grading scale: Fail, Pass