GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Modeling Complex Systems (C004453)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h**

Course offerings in academic year 2025-2026

A (semester 2)	English	Gent

Lecturers in academic year 2025-2026

De Buyl, Sophie	VUB	lecturer-in-charge
Gelens, Lendert	VUB	co-lecturer

Offered in the following programmes in 2025-2026	crdts	offering
Master of Science in Teaching in Science and Technology(main subject Physics and Astronomy)	6	A
Master of Science in Physics and Astronomy	6	A
Master of Science in Physics and Astronomy	6	A

Teaching languages

English

Keywords

Position of the course

https://caliweb.vub.be/?page=course-offer&id=004928&anchor=1&target=pr&year=2223&language=en&output=html
The overall objective of this course is to be able to analyze dynamical systems using geometrical methods on the phase space. This includes carrying out linear stability, bifurcation and phase plane analyses. We will first focus on one and two dimensional systems. Chaotic phenomena in physical systems will be described with two classical examples: the Lorentz strange attractor and the logistic map. Solving problems and reading literature related to the course material is also foreseen.

Contents

- General introduction about linear versus nonlinear dynamics.
- Dynamical systems with one variable.
- Bifurcations in one variable systems: saddle-node, cusp, transcritical and imperfect bifurcations.
- Bifurcations on the circle, synchronisation.
- Linear dynamics with two variables: classification of the fixed points (saddle, node, center, degenerate).
- Nonlinear dynamics with two variables: phase space analysis, reversibility, Lyapunov function, theory of the index.
- Limit cycles: relaxation oscillations, singular perturbation.
- Chaos: Lorentz model and analysis.
- One dimensional maps: bifurcations, period doubling and intermittency route to chaos, universality.
- Fractals: self-similarity, fractal dimension.
- Strange attractors: stretching and folding, baker's map, Henon map.
- Pattern formation.

Initial competences

Final competences

To be able to analyze dynamical systems using geometrical methods on the phase space. This includes carrying out linear stability, bifurcation and phase plane analyses.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Seminar, Lecture, Independent work

Study material

None

References

Course content-related study coaching

Assessment moments

end-of-term assessment

Examination methods in case of periodic assessment during the first examination period

Oral assessment, Written assessment

Examination methods in case of periodic assessment during the second examination period

Oral assessment, Written assessment

Examination methods in case of permanent assessment

Possibilities of retake in case of permanent assessment

not applicable

Extra information on the examination methods

The final grade is composed based on the following categories:
Oral Exam determines 60% of the final mark.
PRAC Presentation determines 40% of the final mark.

Within the Oral Exam category, the following assignments need to be completed:

Written exam with a relative weight of 60 which comprises 60% of the final mark. This is a mid-term test.

Note: oral exam with a written preparation (theory and exercises)

Within the PRAC Presentation category, the following assignments need to be completed:

Presentation with a relative weight of 40 which comprises 40% of the final mark.

Note: presentation of group work (during the classes)

Calculation of the examination mark

- oral exam with a written preparation (theory and exercises) for 60% of the final grade.
- presentation of a group projet (during one of the classes) for 40% of the final grade.