GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2023-2024

Introductory Biophysics (C004229)

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

Credits 6.0 **Study time 180 h**

Course offerings and teaching methods in academic year 2023-2024

A (semester 1)	English	Gent	lecture
			seminar
			group work

Lecturers in academic year 2023-2024

Vandersickel, Nele	WE05	lecturer-in-charge

Offered in the following programmes in 2023-2024	**crdts**	**offering**
Bachelor of Science in Physics and Astronomy	6	A
Exchange programme Faculty of Sciences (bachelor's level)	6	A

Teaching languages

English

Keywords

dynamical systems, Euler integration, equilibria, bifurcation diagrams, non-linear dynamics and chaos, oscillations, limit cycles, neurological model, Python

Position of the course

This course unit belongs to the learning pathway 'Interdisciplinarity & Broadening" in the Bachelor program Physics and Astronomy.
The aim of this course is to learn to model and analyze biological systems. For this we will base ourselves on the book "Modeling of life" by Alan Garfinkel, Jane Shevtsov and Yiba Guo.
Positive and negative feedback are a crucial part of learning to set up the model. For example, we will learn to model an ecosystem of prey (such as tuna) and predators (such as sharks), a typical negative feedback system. Most of the systems we will set up will be non-linear and cannot be solved with pen and paper. Therefore, these must be simulated with the computer to understand the behavior of the system. We will analyse these systems by learning to write scripts in Python.

Contents

- Learning to understand feedback: what is positive and what is negative feedback.
- Converting a system into a differential equation: learning to convert words into mathematics.
- In this course we will model the following systems: population models, feather and friction systems, prey hunter systems, chemical reactions, epidemiology (such as learning to model the Corona virus), neurons, pest outbreak, respiration, food chains, and many others.
- Calculate trajectories of the evolution of the state of a system, via Euler integration.
- Recognize types of equilibria: stable knots, unstable knots, saddle points, stable and unstable coils.
- Method of the nullclines.
- Recognize bifurcations of equilibria: transcritical bifurcation, saddle-node bifurcation, pitch fork bifurcation.
- Recognizing oscillations in systems: in chemistry, biology and physiology.
- Hopf bifurcation: the creation of limit cycles.
- Chaos: in continuous models and in discrete models. Learning to recognize the properties of choas, understanding the routes to a chaotic system.

Initial competences

Basic knowledge of: linear algebra, mathematical analysis, differential equations

Final competences

1 To be able to convert a biological system of words to a differential equation.
2 To be able compute the equilibria in a dynamical system.
3 To be able to compute the trajectory of a system via Euler's method.
4 To be able to analyse the types of bifurcations in a system.
5 To be able to analyse oscillations and limitcycles in a system.
6 To be able to recognize and analyse chaos in a continuous system as well as in a discrete system.
7 To be able to build and analyse a neurological model.
8 To be able to write sripts in Python to analyse a system.

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

Group work, Seminar, Lecture

Extra information on the teaching methods

The lessons will be an alternation of theory and exercises and is divided into 12 parts. The lectures will be made available online, with additional details being given during the lessons. The exercises are worked out by the students during the classes on the computer in Python Notebooks. Students receive new assignments every week. Some of these assignments are worked out by the students every week. Another part must be submitted on week 5 (for 5/20 points) and on week 10 (for 5/20 points). Around week 11, the students receive an assignment that must be completed before the exam. During the exam, each student has to defend his work orally and additional questions are asked.
Each student will receive individual guidance/feedback throughout the year to improve their skills. The students will learn problem-solving thinking and writing clear code.

Learning materials and price

The PDF of Alan Garfinkel's book "Modeling of life" will be shared with the students free of charge via UFORA. If desired, students can also purchase this book online.

References

"Modeling of life" Alan Garfinkel, Jane Shevtsov en Yiba Guo.

Course content-related study coaching

Students can always contact the teacher and the assisting staff with questions about the course (theory and exercises).

Assessment moments

end-of-term and continuous assessment

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

Oral assessment, Assignment

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

Oral assessment, Assignment

Examination methods in case of permanent assessment

Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible in modified form

Extra information on the examination methods

1. Individual work during the year
On week 5 and week 10, the students submit assignments for 5 points each, which can yield a total of 10 points. The teacher retains ultimate responsibility for deviating from the exact moments of evaluation.
2. Individual work with oral defense during the exam period
This work is on the remaining 10/20 points. The students have to give an oral explanation of the work, and additional questions will be asked to check whether the student has mastered the theory.

Each work is checked for plagiarism. The students have to come up with their own solution.

Calculation of the examination mark

- Individual work during the year: 10/20
- Work submitted on the exam with oral defense: 10/20

Facilities for Working Students

To be discussed with the professor