GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Modelling and Simulation of Biosystems (I002445)

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

Credits 4.0 **Study time 120 h**

Course offerings and teaching methods in academic year 2024-2025

A (semester 2)	Dutch	Gent	seminar
			lecture

Lecturers in academic year 2024-2025

Vanhaelewyn, Gauthier	LA26	staff member
Stock, Michiel	LA26	lecturer-in-charge

Offered in the following programmes in 2024-2025	crdts	offering
Bachelor of Science in Bioscience Engineering	4	A
Master of Science in Teaching in Science and Technology(main subject Mathematics)	4	A
Master of Science in Bioinformatics(main subject Bioscience Engineering)	4	A
Master of Science in Mathematics	4	A

Teaching languages

Dutch

Keywords

Biosystem dynamics, modeling, simulation, sampling, Bayesian reasoning, sensitivity analysis, parameter estimation, uncertainty analysis, model selection, optimization

Position of the course

This course applies the basic principles learned in the various basic mathematics courses in 1st and 2nd Ba to biosystems. The student learns to analyze a biosystem in a mathematical way. The focus is on both dynamic models (described by differential equations) and stochastic models.

Contents

Course structure:

1 General introduction
2 Modeling with probability distributions and the Monte Carlo method
3 Sampling methods and the Bayesian perspective
4 Modeling with differential equations
5 Computational and numerical methods for differential equations
6 Mathematical optimization
7 Parameter estimation and model selection
8 Uncertainty and sensitivity analysis

Initial competences

Modeling and simulating biosystems builds on specific final competencies of the course units 'Scientific Programming', 'Differential Equations' and 'Probabilistic Models'; or the final competencies were acquired in another way. The examples and exercises are inspired by principles of other courses throughout the Bachelor of Bioscience Engineering.

Final competences

1 Students can recognize and describe the general modeling principles.
2 Students can combine elementary probability distributions into a complex, hierarchical model and can generate samples and make inferences from this.

3 Students are familiar with the most important sampling-based inference techniques and can apply them.
4 Students can set up models based on differential equations on the basis of mass balances and known kinetics and calculate them.
5 Students are familiar with the general principles for estimating parameters of their model based on data.
6 Students can estimate the uncertainty and sensitivity of their parameters and model inputs.
7 Apply a Monte Carlo procedure to a mathematical model
8 Students have insight into how mathematical optimization can be used for parameter estimation and process optimization.
9 Students have insight into model selection and the role of model complexity.
10 Students can use modern software to build and simulate models.

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

Extra information on the teaching methods

The theory is presented in lectures. The exercises are provided through seminars that consist of board exercises and simulation exercises in a notebook environment. Additional problems are provided for self-study.

Study material

Type: Syllabus

Name: Course modeling and simulation
Indicative price: € 15
Optional: no
Language : English

References

- Meadows, D.H., 2008. *Thinking in Systems: A Primer*. Chelsea Green Publishing.
- Novak, K., 2022. *Numerical Methods for Scientific Computing*, Second Edition. ed. Equal Share Press.
- Downey, A., 2022. *Modeling and Simulation in Python.* No Starch Press.
- Additional primary sources.

Course content-related study coaching

We will only support students during lecture hours or via the UFORA platform (Discussion Forum).

Assessment moments

end-of-term assessment

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

Written assessment, Assignment

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

Written assessment, Assignment

Examination methods in case of permanent assessment

Possibilities of retake in case of permanent assessment

not applicable

Extra information on the examination methods

Students are evaluated on their knowledge of the concepts through a written, closed-book exam. Analogous to the PC-labs, the practical knowledge is evaluated using an open-book computer exam.
In addition, students must also complete a project in which they apply the principles of the course to an example relevant to bioengineering sciences.

Calculation of the examination mark

Evaluation: the exam consists of theory questions (approx. 50%) and PC exercises (approx. 50%).
The project has a score of 5/20 points.
The examiner can declare a student who eschews periodic and/or non-periodical evaluations for this course unit failed.