

## Modelling and Simulation of Biosystems (1002445)

**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 2025-2026**

A (semester 2)

Dutch

Gent

seminar

lecture

**Lecturers in academic year 2025-2026**

Vanhaelewyn, Gauthier

LA26

staff member

Stock, Michiel

LA26

lecturer-in-charge

**Offered in the following programmes in 2025-2026**

[Bachelor of Science in Bioscience Engineering](#)

**crdts**

4

**offering**

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 (described by differential equations) and stochastic models.

**Contents**

**Course structure:**

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

**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 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. 1/3) and PC exercises (approx. 2/3).

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.