GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2024-2025

Mathematical Modeling (C004010)

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 2024-2025

A (semester 1)	Dutch	Gent	lecture
			seminar

Lecturers in academic year 2024-2025

Van Daele, Marnix	WE02	lecturer-in-charge

Offered in the following programmes in 2024-2025	**crdts**	**offering**
Bachelor of Science in Mathematics	6	A

Teaching languages

Dutch

Keywords

model, modelling
differential equation
dynamical system, bifurcation
singular-value-decomposition

Position of the course

Chronologically this is one of the last courses in the bachelor program in mathematics that is mandatory for all students. It relies on the knowledge acquired in several previous courses (linear algebra, analysis, numerical analysis) and points to practical applications of this knowledge.

Contents

In the first chapter, we discuss what 'applied mathematics' is, which kind of problems are studied and what the role of mathematical modelling is in solving problems. Distinction is made between different kinds of models (continuous and discrete models, deterministic and stochastic models, ...).
We discuss the Singular value decomposition since it is an important tool to help understand what the impact is of a matrix. This decomposition is also the basis of several important algorithms.
Responding to current events, the study of the evolution of epidemiological diseases through compartmental models is discussed in more detail.
This is followed by a qualitative analysis of one-dimensional and two-dimensional dynamical systems with an introduction of general concepts of dynamical systems and bifurcation theory.
More attention is paid to Hamiltonian problems (with emphasis on the symplecticity of the solutions) and Sturm-Liouville problems (as an example of eigenvalue problems).

Initial competences

Final competences of the courses Analysis I and Analysis II, Linear Algebra and Geometry I and Numerical Analysis.

Final competences

1 To know modelling techniques and interpret them.
2 Know which bifurcations can be expected in a particular situation. Compute

bifurcation points and their normal form. Do a complete two-parameter bifurcation analysis.
3 Understand properties of solutions of some specific problems (such as Sturm-Liouville problems and Hamiltonian problems).
4 Be able to compute the singular value decomposition and to have insight in applications of this decomposition.

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

Exercises with paper and pencil, but also with computer and specialized software.

Study material

Type: Handbook

Name: Geometric Numerical Integration
Indicative price: € 180
Optional: yes
Language : English
Author : Hairer, Wanner and Lubich
ISBN : 978-3-64205-157-9
Number of Pages : 644
Online Available : No
Available in the Library : Yes
Available through Student Association : No
Usability and Lifetime within the Course Unit : regularly
Usability and Lifetime within the Study Programme : one-time
Usability and Lifetime after the Study Programme : not
Additional information: This book can be used for the chapters on Hamiltonian problems and symplectic integration

Type: Handbook

Name: Numerical Linear Algebra
Indicative price: € 50
Optional: yes
Language : English
Author : Trefethen and Bau
ISBN : 0-898-71361-7
Number of Pages : 373
Oldest Usable Edition : 1997
Online Available : No
Available in the Library : Yes
Available through Student Association : No
Usability and Lifetime within the Course Unit : one-time
Usability and Lifetime within the Study Programme : one-time
Usability and Lifetime after the Study Programme : not
Additional information: This book provides more information about the SVD

Type: Handbook

Name: Nonlinear dynamics and chaos
Indicative price: € 70
Optional: yes
Language : English
Author : Strogatz
ISBN : 978-0-81334-910-7
Number of Pages : 513
Online Available : No
Available in the Library : Yes
Available through Student Association : No
Usability and Lifetime within the Course Unit : regularly

Usability and Lifetime within the Study Programme : one-time
Usability and Lifetime after the Study Programme : not
Additional information: The part on Dynamical Systems is based on this book.

Type: Syllabus

Name: Mathematical Modelling
Indicative price: Free or paid by faculty
Optional: no
Language : Dutch
Number of Pages : 235
Oldest Usable Edition : 2023
Available on Ufora : Yes
Online Available : No
Available in the Library : No
Available through Student Association : No

References

The Princeton Companion to Applied mathematics, editor Nicholas J. Higham, Princeton University Press, 2015
Numerical Solution of Sturm-Liouville Problems, Johan D. Pryce, Clarendon Press, 1993,
Numerical Linear Algebra, Lloyd N. Trefethen, David Bau, III, Siam, Philadelphia, 1997

Course content-related study coaching

Individual contact with the lecturer, electronic environment Ufora.

Assessment moments

end-of-term and continuous assessment

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

Written assessment

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

Written assessment

Examination methods in case of permanent assessment

Oral assessment, Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible

Extra information on the examination methods

End-of-term evaluation: written examination at the end of the semester in closed book form and open book form.
Permanent evaluation: handed in projects.
The evaluation evaluates both the practical (programming an algorithm in a project) as well as the theoretical skills (knowledge of basic definitions, understanding of derivations, ...).

Calculation of the examination mark

Theory: 8 marks (out of 20).
Exercises: 8 marks (out of 20).
Project : 4 marks (out of 20).