

## Advanced Numerical Methods (C004011)

**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 2)

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**

[Master of Science in Teaching in Science and Technology\(main subject Mathematics\)](#)

**crdts**

6

**offering**

A

[Master of Science in Computer Science](#)

6

A

[Master of Science in Mathematics](#)

6

A

**Teaching languages**

Dutch

**Keywords**

Numerical methods, linear multistep methods, Runge-Kutta methods, stability, accuracy  
Ordinary differential equations; partial differential equations

**Position of the course**

Differential equations appear in all kinds of applications. Their solutions however can rarely be written down in a closed form and so a numerical, approximative procedure is needed. The aim of this course is

- to make students acquainted with the most important classes of numerical methods for solving ordinary and partial differential equations.
- to teach students to use modern computer tools for solving differential equations.

**Contents**

- 1 Overview of the most important properties of numerical methods for ordinary differential equations: zero-stability and consistency, order, implicit and explicit methods, stability.
- 2 Multistep methods: construction (Adams type and BDF type), order, stability, error estimation, PC-pairs.
- 3 Runge-Kutta-methods: construction using the Butcher theory, order, stability, error estimation, collocation methods.
- 4 Partial differential equations : treatment of some standard equations of parabolic, hyperbolic and elliptic kind.

**Initial competences**

In the second year the student have studied a first course in het field of numerical analysis. The last chapter of that course gives a brief introduction to this course. In the final semester of the bachelor programme there is also the course Mathematical Modelling, in which some numerical methods were discussed.

Also, the students are acquainted with analysis and algebra and on the other hand, the students also have the skills to implement algorithms on a computer.

**Final competences**

- 1 The students have learnt how to become intelligent users of state-of-the-art software for solving differential equations: this means that the students have insight into the characteristics of the most important classes of numerical methods and they understand how and when to apply these methods.

- 2 The students understand the mathematical ideas underlying the numerical methods.
- 3 Students know where to find professional software and how to deal with it.

### 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

Also Ufora and ILONA (<http://www.ilona.ugent.be/>) will be used.  
On request the learning material can be provided in English.

### Study material

Type: Handbook

Name: Numerical methods for ordinary differential equations  
Indicative price: € 100  
Optional: yes  
Language : English  
Author : Lambert  
ISBN : 978-0-47192-990-1  
Number of Pages : 304  
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

Type: Syllabus

Name: Advanced numerical methods  
Indicative price: Free or paid by faculty  
Optional: no  
Language : Dutch  
Number of Pages : 227  
Oldest Usable Edition : 2020  
Available on Ufora : Yes  
Online Available : No  
Available in the Library : No  
Available through Student Association : No

### References

E. Hairer, S. Norsett, G. Wanner, Solving ordinary differential equations I, Nonstiff problems, Springer, 2nd Edition, 1993.  
E. Hairer, S. Norsett, Solving ordinary differential equations II, Stiff and Differential-Algebraic Problems, Springer, 2nd Edition, 1996.  
K.W. Morton and D.F. Mayers, Numerical Solution of Partial Differential Equations, Cambridge University Press, 1994

### Course content-related study coaching

The students can make an appointment with the lecturer to have some extra individual coaching.

### Assessment moments

end-of-term and continuous assessment

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

Written assessment with open-ended questions

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

Oral assessment, Written assessment with open-ended questions

### Examination methods in case of permanent 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.

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, understanding of the mechanisms which make a given method better than other methods, ...).

**Calculation of the examination mark**

Continuous (20 %) and end-of-term assessment (80%)