Linnæus University

Dnr: LNU-2024/242

Course syllabus

Faculty of Technology
Department of Mathematics

4MA902 Numerisk analys av PDE, 7,5 högskolepoäng
Numerical Analysis of PDE, 7.5 credits

Main field of study
Mathematics

Subject
Mathematics

Level
Second cycle

Progression
A1F

Date of Ratification
Approved 2024-01-29.
The course syllabus is valid from autumn semester 2024.

Prerequisites
Numerical Methods, 5 credits (1MA930 or 1MA931),
Introduction to Applied Analysis, 7.5 credits (4MA901) or
Functional analysis, 7.5 credits (4MA415)

Objectives

After completing the course, the student should be able to:
Knowledge and Understanding

- A.1 Demonstrate understanding of existence, uniqueness, and regularity theory for linear partial differential equations (PDEs) and describe its relevance to numerical methods.
- A.2 Describe the strengths and weaknesses of commonly used numerical methods for discretizing elliptic, parabolic, and hyperbolic differential equations.

- A.3 Explain the relevance of central concepts in numerical analysis.
- A.4 Derive error estimates for finite element and finite difference methods for PDEs.

Skills and Abilities

- B.1 Demonstrate the ability to, based on a general question involving partial derivatives, formulate an adequate mathematical problem, and use and integrate knowledge to analyze, structure, and solve problems.
- B.2 Demonstrate the ability to plan and implement adequate numerical methods, and within given frameworks, carry out qualified tasks in computational mathematics and present the results in a report.
- B.3 Demonstrate the ability to work in a team and collaborate in a group.

Critical Evaluation and Approach

- C.1 Demonstrate the ability to interpret, compare,

Content

The course provides advanced knowledge in the analysis of numerical methods for solving PDEs. Commonly used methods are derived in detail and numerical analysis is presented. In one or more mandatory assignments, finite element methods are implemented with a reflection on the results based on theoretical understanding.

The following topics are covered:

- Introduction to elliptic, parabolic, and hyperbolic partial differential equations
- Finite element and finite difference methods for elliptic equations
- The finite element method for elliptic eigenvalue problems
- Finite element and finite difference methods for parabolic equations
- Basic theory for finite element and finite difference methods for hyperbolic equations
- Basic theory for numerical solution of PDEs with non-linear terms

Type of Instruction

Lectures, teacher-led problem-solving sessions, and teacher-led meetings related to the assignments. Assignments are carried out in groups of 2-4 students.

Examination

The course is assessed with the grades A, B, C, D, E or F.

To pass the course, a minimum grade of E is required on the theory and problem-solving module, and a grade of G (Pass) on the assignments. The final grade is determined by the grade on the theory and problem-solving module.

The theory and problem-solving module is examined individually with a written exam. For the assignments, results from both written and oral presentations are noted. Together, these form the basis for grading the graded component. The assignments are examined in groups.

Resit examination is offered in accordance with Linnaeus University’s Local

regulations for courses and examination at the first- and second-cycle levels. In the event that a student with a disability is entitled to special study support, the examiner will decide on adapted or alternative examination arrangements.

Objectives achievement

The examination of the course is divided as follows:
Module 2401 Exam: Theory and problem solving 5.0 credits with the grading system AF
Module 2402 Assignment 2.5 credits with the grading system UG

The examination elements are linked to the course objectives in the following ways:
Module 2401 links to the course objectives: A.1, A.2, A.3, A.4, B.1, C.1
Module 2402 links to the course objectives: A.1, A.2, B.1, B.2, B.3, C.1

Course Evaluation

A course evaluation should be conducted during the course or in connection with its conclusion. The results and analysis of the completed course evaluation should be promptly communicated to students who have completed the course. Students participating in the next course instance should be informed of the results of the previous course evaluation and any improvements that have been made, no later than at the start of the course.

Overlap

The course cannot be included in a degree along with the following course/courses of which the content fully, or partly, corresponds to the content of this course:
4MA404, 2.5 credits and 4MA403, 2.5 credits

Other Information

The course is conducted in such a way that the experiences and knowledge of the course participants are made visible and developed. This means, for example, that we have an inclusive approach and strive to ensure that no one feels excluded. This can manifest itself in different ways in a course, for example, by the teacher using gender-neutral examples.

Required Reading and Additional Study Material

Required Literature:

- Larsson, Stig and Thomée, Vidar, Partial Differential Equations with Numerical Methods, Springer, latest edition.
- Complementary mathematical study material from the department.

Recommended Reading:

- Larson, Mats G. and Bengzon, Fredrik, The Finite Element Method: Theory, Implementation, and Applications, Springer, latest edition.
- Thomée, Vidar, Galerkin Finite Element Methods for Parabolic Problems, Springer, latest edition.