Faculty of Science

NUMN23, Numerical Analysis: Iterative Solution of Large Scale Systems in Scientific Computing, 7.5 credits

Numerisk analys: Iterativ lösning av storskaliga system i beräkningsteknik, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2020-05-19 to be valid from 2020-05-19, spring semester 2021.

General Information

The course is an elective course for second-cycle studies for a Degree of Master of Science in mathematics.

Language of instruction: English

Main field of studies	*Depth of study relative to the degree requirements*
Mathematics	A1F, Second cycle, has second-cycle course/s as entry requirements

Learning outcomes

The main goal of the course is to give an overview into modern iterative methods that are used to solve large-scale nonlinear and linear equation systems that arise within Scientific Computing, especially in the numerical treatment of partial differential equations.

Knowledge and understanding

On completion of the course, the student should be able to:

- give an account of basic iterative methods for linear and nonlinear equations and the mathematical differences between them,
- describe the structure of Jacobian-free Newton-Krylov methods,

- describe multi-grid methods and their use on some model problems.

Competence and skills

On completion of the course, the student should be able to:

- implement an inexact Jacobian-free Newton-Krylov method,
- implement a multi-grid method and apply it to model problems,
- implement basic iterative solution methods,
- integrate knowledge from the various parts of the course to address questions within a computational project,
- plan and execute qualified tasks with appropriate methods, within given time-frames.

Judgement and approach

After completing the course the student should be able to:

- analyse a given linear or nonlinear equation system and determine which solution methods are suitable,
- critically evaluate and independently apply methods within a project work,
- evaluate their own responsibility for how the subject is used and discuss the subject's possibility to contribute to a sustainable social development.

Course content

The course treats:

- How large-scale linear and nonlinear systems arise in Scientific Computing
- Rate of convergence
- Termination criteria
- Basic iterative methods for linear and nonlinear equations (Fixed Point Methods, Newton's Method, Inexact Newton's Method, methods of Newton type) as well as their convergence properties and weaknesses
- Linear systems
- Krylov subspaces and Generalized Minimum RESidual Method (GMRES)
- GMRES with preconditioning
- Jacobian-free Newton-Krylov methods
- Multi-grid methods in one and two dimensions
- Multi-grid methods for nonstandard equations and for nonlinear systems.

Course design

The teaching consists of lectures. Assignments and a compulsory final project are included in the course. The assignments are not compulsory, but they are preparatory for the compulsory final project.

Assessment

The examination consists of a written report of the final project and an appurtenant oral examination. The oral examination is given only to those students who have passed the written report.

Students who fail the regular examination are offered a re-examination shortly thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Subcourses that are part of this course can be found in an appendix at the end of this document.

Grades

Marking scale: Fail, Pass, Pass with distinction.
To obtain the grade Pass, the student is required to pass the project report and the oral examination of the final project. Grading scale on the Project report is Fail and Pass, and for the oral examination of the final Project the grading scale is Fail, Pass and Pass with distinction. To obtain the grade Pass with distinction it is required in addition that the student demonstrates a good ability to critically and systematically integrate knowledge from the various parts of the course and handle, analyse and assess various questions posed in the project and at the oral examination.

Entry requirements

For admission to the course, English 6 / B and knowledge equivalent to 90 credits in mathematics and numerical analysis are required, including the course NUMN20 Numerical Methods for Differential Equations, 7.5 credits or equivalent.

Further information

The course cannot be credited in the degree together with NUMN30 Iterative solution of large-scale systems in computational technology, 7.5 credits.

The course is to be studied together with FMNN30 Iterative solution of large-scale systems in computational technology, 7.5 credits, which is coordinated by LTH.

Subcourses in NUMN23, Numerical Analysis: Iterative Solution of Large Scale Systems in Scientific Computing

Applies from V21

2101 Written Project Report, 3,5 hp
Grading scale: Fail, Pass
2102 Oral Examination, 4,0 hp
Grading scale: Fail, Pass, Pass with distinction