FSF3570 Numerical Methods for Boundary Integral Equations 7.5 credits

Numeriska metoder för randintegralekvationer

This is a translation of the Swedish, legally binding, course syllabus.

If the course is discontinued, students may request to be examined during the following two academic years

Establishment

Course syllabus for FSF3570 valid from Autumn 2018

Grading scale

P, F

Education cycle

Third cycle

Specific prerequisites

A Master degree including at least 30 university credits (hp) in in Mathematics (including differential equations, numerical analysis and numerical methods for differential equations). Does not require previous experience with boundary integral equations.

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

After completion of the course the student should be able to:

- Design a solution algorithm for a collocation scheme discretizing a boundary integral equation to solve the Laplace or Stokes equations for 2D geometries and a simple 3D-geometry. Motivate the choices made and discuss the accuracy of the solution.
- Identify strengths and weaknesses about boundary integral methods. Argue about if a boundary integral method is advantageous to use for a specific problem, and how it compares to other well-established solution methods.

As smaller sub-goals, the student should specifically be able to:

- Formulate the Laplace and Stokes equations as boundary integral equations (BIE).
- Explain key concepts of the mathematical theory for integral equations (e.g. properties of integral equations of the first and second kind, practical consequences) and of theory specific to Stokes flow (e.g. Lorentz reciprocal theorem).
- Work with complex variable formulations of integral equations in 2D and build discretizations based on these.
- Explain what difficulties arise in the design of quadrature formulas for BIEs, and some techniques that can remedy these difficulties.
- Describe the need of so called "fast summation methods". Explain the underlying ideas of the Fast Multipole Method (FMM) and particle-mesh Ewald methods.

Course contents

Numerical methods for boundary integral equations, mainly for the Laplace equation and Stokes flow. Derivation and main mathematical properties of integral equations.

Topics to be discussed include:

- Theory for integral equations, and specifically boundary integral equations. Starting with the Laplace equation, then moving on to Stokes equations. Single layer and double layer formulations.
- Numerical discretization of boundary integral equations, primarily collocation methods.
- Quadrature rules, including singularity treatments.
- Fast summation methods. FFT based methods, fast multipole method (FMM).
- Periodicity treatment. Theory and practical methods.

Disposition

This course is typically given based on self-studies and group discussions, but can include lectures depending on the number of students.

Course literature

To be announced before the course starts.

Examination

- INL1 - Assignments, 7.5 credits, grading scale: P, F

Based on recommendation from KTH's coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

Topic for final course project can be suggested by student but must be approved by examiner.

Other requirements for final grade

Assignments completed (combination of theoretical and numerical including implementations). Final course project completed.

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.