FAF3702 Applications of Partial Differential Equations in Fluid Mechanics 7.5 credits

Partiella differentialekvationer med tillämpningar inom strömningslära

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 FAF3702 valid from Autumn 2011

Grading scale

Education cycle

Third cycle

Specific prerequisites

Language of instruction

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

Intended learning outcomes

After finishing the course, the student should be able to
-understand the derivation of some basic partial differential equations (PDE) such as the heat equation, Reynolds Transport equation and the Navier -Stokes Equation, in Cartesian, spherical and cylindrical coordinates.
- to use numerical methods (finite volume method), Fourier method and (in some special cases) analytical methods as part of solving PDE.
- to write own computer programs for solving PDE, and programs for the visualization and animation of the solutions.
- analyze consistency, convergence and stability of numerical methods for solving PDE.

Course contents

Introduction: Vector and scalar fields in Cartesian, cylindrical and spherical coordinates. Ordinary differential equations. Flow visualization: Streamlines, streamtubes, pathlines, streaklines, timelines. Strain rate tensor. Flux integrals and applications.

Partial differential equations (PDE).
Classification of Partial differential equations.
Boundary-value problems.
Solving PDE using Fourier series and some analytical methods.
Finite volume and finite difference numerical methods for PDE.
Iterative methods for systems of linear and nonlinear equations. Banach fixed point theorem.

Jacobi method, Gauss–Seidel method, the Successive over-relaxation method, Newton method and Gradient method.
Consistence, convergence and stability of solution methods.
Fourier-von Neumann stability analysis. Lax equivalence theorem
Heat equation and diffusion equation in 3D.
Laplace equation. Wave equation. Vibrating strings and membranes.
Conservation of mass- The continuity equation
The Reynolds Transport equation.
Stress tensor and Cauchy’s equation
The Navier -Stokes Equations
Turbulence and its modeling. Reynolds-averaged Navier-Stokes equations.
The finite volume method for convection-diffusion problems.
The finite volume method for some unsteady flows.
SIMPLE, SIMPLER, SIMPLEC and PISO algorithm.

Course literature

1. Versteeg, H.K. and Malalasekera, W., “An Introduction to Computational Fluid Dynamics : The Finite Volume Method”, Second Edition, Pearson Education Ltd.,2007, ISBN 0-978-0-13-127498-3.
2.Richard Haberman, Applied Partial Differential Equations, 4/E. Pearson Education Ltd., ISBN-10: 0130652431. ISBN-13: 9780130652430
3. Randall J. Leveque: Finite Volume Methods for Hyperbolic Problems, **ISBN**-13: 978-0521009249

Examination

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.

Other requirements for final grade

- TEN1 - Examination, 5.5 credits
- LAB1 - Laboratory Work, 2 credits

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.