Computational Fluid Dynamics (5C1212), 5p.

Lecturers:

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Office hours: Mon 16-18 and Wed 16-18.

Literature:

Computational Fluid Dynamics, John D. Anderson, Jr., McGraw-Hill, 1995, (And)

D. Henningson, *Lecture notes on Computational Fluid Dynamics*

K. Gustavsson, *Lecture notes on Basic Numerics*

Grading:

Test total of 50p., homeworks (required) $3 \times 5 = 15$p.

Total points > 30 (3), > 40 (4), > 50 (5).

Web links

`http://www.mech.kth.se/`
`http://www.nada.kth.se/~katarina`

Course plan

1. Wen 18/1 8-10, L51. Fluid dynamics I: EÅ

   Introduction and outline of the course.

   Derivation of the governing equations.

2. Fri 20/1 10-12, L51. Basic numerics I: KG

   Mathematical behavior of hyperbolic, parabolic and elliptic equations. Well-posedness.

3. Fri 20/1 13-15, L51. Fluid dynamics II: EÅ

   Derivation of the governing equations , cont.

4. Mon 23/1 10-12 L52. Basic numerics II: KG

   Discretization by finite differences. Analysis of discretized equations; order of accuracy, convergence and stability (von Neumann analysis).

5. Tue 24/1 10-12, E2. Fluid dynamics III: EÅ

   Derivation of the governing equations , cont.

6. Wed 25/1 10-12, L51. Basic numerics III: KG

   Analysis of discretized equations, cont.

7. Fri 27/1 10-12, V22. Fluid dynamics IV: EÅ

   Dimensionless form, fluid phenomena, simplified equations

8. Mon 30/1 10-12, L52. Basic numerics IV: KG

   Numerical methods for model equations.

9. Wen 1/2 8-10, Q35. Compressible flow I: KG

   Introduction to compressible flow. Euler equations, conservative/non-conservative form. Some thermodynamics.

10. Fri 3/2 13-15, V22. Compressible flow II: KG

    Scalar conservations laws. Numerical methods for scalar conservation laws.

11. Tue 7/2 10-12, Q34. Compressible flow III: KG

    System of conservation laws (Euler equations).

12. Wen 8/2 10-12, D3. Compressible flow IV: KG

    Numerical methods for systems of conservation laws. Boundary conditions. Shock tube.

13. Fri 10/2 10-12, Q35. Compressible flow V: KG

    Numerical methods for Euler equations. Riemann invariants.

14. Mon 13/2 10-12, L52. Compressible flow VI: KG

    Numerical methods for Euler equations, cont. Nozzle flow.

15. Tue 14/2 10-12, Q34. Finite volume and finite difference methods I: DH

    Laplace equation on arbitrary grids, equivalence with finite-differences, linear systems: Gauss-Seidel as smothers for multi-grid.

16. Fri 17/2 10-12, V22. Finite volume and finite difference methods II: DH

    Introduction to incompressible flow. Properties of the equations, role of the pressure: artificial compressibility and projection on divergence free space, Navier-Stokes in integral form.

17. Mon 20/2 10-12, L52. Finite volume and finite difference methods III: DH

    Staggered grid/volume formulation + BC. Unsteady equations: projection and MAC method, discrete Poisson pressure eq.

18. Mon 20/2 13-15, L52. Finite volume and finite difference methods IV: DH

    Time step restrictions. Steady equations: distributive iteration and SIMPLE methods.

19. Wen 22/2 8-10, Q35. Finite elements I: DH

    An advection–diffusion problem. Variational form of the equation, weak solutions, essential and natural boundary condition. Finite-element approximations, stability and accuracy, the algebraic problem, matrix assembly.

20. Mon 27/2 10-12, B3. Finite elements II: DH

    Navier–Stokes equations. Mixed variational form, Galerkin and FE approximations, the algebraic problem. Stability, the LBB condition, mass conservation.

21. Wen 1/3 10-12, V32. Finite elements III: DH

    Navier–Stokes equations. Mixed variational form, Galerkin and FE approximations, the algebraic problem. Stability, the LBB condition, mass conservation.

22. Fri 3/3 10-12, V3. Finite elements IV: DH

    Navier–Stokes equations. Mixed variational form, Galerkin and FE approximations, the algebraic problem. Stability, the LBB condition, mass conservation.

23. Fri 10/3 14-18, M34,M35,M36. EXAM.

24. Mon 5/6 9-13, E51. EXAM.

Homeworks

- Homework 1A, due 1/2: Homework on NS equations.
- Homework 1B, due 1/2: Numerical methods for model equations. Different schemes. Dispersion, diffusion. Stability analysis.

  NOTE: you do either hw 1A OR hw 1B
- Homework 2, due 13/2: Numerical methods for non-linear conservation laws. Shock-tube.
- Homework 3, due 20/2: Quasi-1D Nozzle Flow
- Homework 4, due 1/3: FV homework + numerical project.
- Homework 5, due 10/3: FEM homework.