SME5802 – 2016
Introdução à Mecânica dos Fluidos Computacional
Introduction to Computational Fluid Dynamics
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Terças–feiras, 14–17 hs, Sala 5-101.

1. **Principles and equations of Fluid Mechanics**: The continuum hypothesis. Definition of fluid. Eulerian and Lagrangian frames. Material derivative and transport theorem. Conservation principles. Thermodynamics. Incompressibility. Viscosity. Non-newtonian behavior. Turbulence. Reference: Chapter 1 of Wesseling. Expected: 08/09.
2. **Discretization methods at a glance**: Prototype elliptic and parabolic equation. Strong formulation, integral formulation, weak formulation. Finite differences, finite volumes, finite elements. Other discretization schemes at a glance. Expected: 08/23.
3. **Fully developed flow**: Laminar fully developed flow. Boundary conditions. Parallel plates, circular pipe. Pipe of arbitrary cross section. Expected: 08/30.
4. **A bit of turbulence**: Turbulent pipe flow. Moody diagram. Turbulence model. Expected: 09/13.
5. **Diffusion, convection and upwinding**: Convection-diffusion equations. Term by term discussion. Boundary layers. Incorporating reaction terms. Discretization. Upwinding in finite volumes. Expected: 09/20.
6. **Incompressible Navier-Stokes equations and related models**: Navier-Stokes equations. Incompressibility. Vorticity. Bernoulli's principle. Streamfunction. The pressure. Projection structure. Buoyancy effects. Boundary conditions at walls, free surfaces, capillary surfaces, etc. Integral form. Expected: 09/27.
7. **Discretization of the incompressible Navier-Stokes equations**: Collocated and staggered grids. Finite volume formulations. Solution strategies: Monolithic and segregated. Deformable domains: Arbitrary Lagrangian-Eulerian formulation. Expected: 10/04.
8. **Hyperbolic conservation laws**: Hyperbolic equations and systems. Rankine-Hugoniot conditions. Traffic flow. Burgers' equation. Acoustic equations. Shallow water equations. Linearization. Expected: 10/18.
9. **Finite volume methods for conservation laws**: Weak solutions and general scheme. Upwinding. First order schemes. Lax-Wendroff scheme. Godunov-type schemes. Riemann solvers. Application to the acoustic equations and to the linearized shallow water equations. Expected: 10/25.
10. **Finite volume methods for nonlinear systems**: Approximation of the shallow water equations. Shocks and rarefaction waves. Expected: 11/01.

Work load: 3 hours in class, 3 reading, 6 doing exercises and small projects, per week.

Grades: Oral examinations every week, plus a couple of small project reports.

Bibliography
WESSELING. Principles of Computational Fluid Dynamics.
LEVEQUE. Finite-volume Methods for Hyperbolic Problems.
HIRSCH. Numerical computation of internal and external flows.
KIRBY. Micro- and Nanoscale Fluid Mechanics.