ME-571 **Numerical methods in heat transfer**

Cursus	Sem.	Type
Computational science and Engineering	MA2, MA4	Opt.
Energy Management and Sustainability	MA2, MA4	Opt.
Mechanical engineering	MA2, MA4	Opt.

Language of teaching	English
Credits	3
Withdrawal	Unauthorized
Session	Summer
Semester	Spring
Exam	During the semester
Workload	90h
Weeks	14
Hours	**3 weekly**
Courses	3 weekly
Number of positions	

It is not allowed to withdraw from this subject after the registration deadline.

Remark

pas donné en 2017-18

Summary

This course covers the basic aspects of the numerical discretization and solution of the fluid flow and heat transfer equations within the finite volumes framework. Emphasis is on developing a in-house solver and on utilizing opensource CFD tools for more complex flow and heat transfer problems

Content

This course has a very practical approach. Participants will learn the foundations of the numerical discretization based on the finite volumes method by implementing a simplified solver in Matlab to solve simple 1D and 2D fluid flow and heat transfer problems. Afterwards, participants will learn how to setup and solve flow and heat transfer problems in more complex geometries by means of opensource CFD tools (OpenFOAM and Paraview).

- Review of Navier-Stokes and heat conduction/convection equations
- Finite volume method
- Steady and unsteady 1D and 2D heat conduction (Matlab, OpenFOAM)
- Direct and iterative methods for the solution of the system of linear equations
- Grid convergence analysis
- Heat conduction/convection problems
- Solution of flow field in 1D, staggered grids, pressure-velocity coupling (Matlab)
- Laminar flow field and heat transfer in 2D and 3D (OpenFOAM)
- Visualization and post-processing (Paraview)

Keywords

Numerical simulation, finite volumes method, fluid mechanics, heat transfer

Learning Prerequisites

Required courses

- Incompressible fluid mechanics (ME-344)

- Heat and mass transfer (ME-341)

Recommended courses

- Discretization methods in fluids (ME-371)
- Numerical analysis (MATH-251)

Important concepts to start the course

- Explain and apply the concepts of mass, energy, and momentum balance, E1
- Explain and apply the concepts of heat and mass transfer, E3
- Define, describe and apply the basic flow equations, such as the Navier-Stokes equations, AH17
- Describe flow in simple geometries, such as over a flat plate, in a tube, or around a sphere or airfoil, AH11
- Understand the basics of computer programming; develop a (simple) structures software using a programming language / environment such as C, Fortran or Matlab, AH40
- Analyse numerical solutions and identify any inconsistencies with respect to physical reality; understand and apply the concepts of verification and validation, AH29
- Describe different methods used to discretize differential equations, such as finite differences, finite elements, finite volumes, lattice Boltzmann, SPH, AH30

Learning Outcomes

By the end of the course, the student must be able to:

- Identify the crucial aspects present in a real flow in order to propose an appropriate modelling, AH10
- State the conserved quantities in a given flow and link them to a physical-mathematical description, AH16
- Identify and apply the different steps in a numerical simulation (e.g. geometry and mesh generation, computation, post-processing) and integrate all the essential basic concepts in a numerical flow simulation, AH23
- Assess / Evaluate numerical accuracy as a function of the choice of simulation parameters, AH28
- Analyze numerical solutions and identify any inconsistencies with respect to physical reality; understand and apply the concepts of verification and validation, AH29
- Perform a numerical simulation with appropriate software; understand the limits of each software in terms of its application domain and accuracy of the results obtained, AH41

Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Use both general and domain specific IT resources and tools
- Continue to work through difficulties or initial failure to find optimal solutions.
- Write a scientific or technical report.

Teaching methods

Lectures (about 50% of the classroom time), followed by practical exercises (remaining 50%) at the computer. Weekly assignements.

Expected student activities

Participation in classroom (practical exercises), assignments, final report.

Assessment methods

The participants have to prepare a final report describing the methodology applied to solve the assignments and the related results. The report must be handed to the teacher by the end of the course. The assessment of the student is based on the evaluation of the final report.

Supervision

Office hours	No
Assistants	No
Forum	Yes

Resources

Bibliography

- Hand-outs given during the course.
- Fundamentals of Heat and Mass Transfer - Incropera et al. (2002)
- Numerical Heat Transfer and Fluid Flow - Patankar (1980)
- Computational Methods for Fluid Dynamics - Ferziger and Peric (1999)
- An introduction to computational fluid dynamics: the finite volume method - Versteeg and Malalasekera, 2nd edition (2007)

Ressources en bibliothèque

- Fundamentals of heat and mass transfer / Incropera
- Numerical heat transfer and fluid flow / Patankar
- Computational methods for fluid dynamics / Ferziger

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=15111