ME-474 **Numerical flow simulation**

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Cursus	Sem.	Type
Computational science and Engineering	MA1, MA3	Opt.
Energy Management and Sustainability	MA1, MA3	Opt.
Mechanical engineering	MA1, MA3	Opt.

Language of teaching	English
Credits	5
Withdrawal	Unauthorized
Session	Winter
Semester	Fall
Exam	During the semester
Workload	150h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Il n'est pas autorisé de se retirer de cette matière après le délai d'inscription.

Summary

This course provides practical experience in the numerical simulation of fluid flows. Numerical methods are presented in the framework of the finite volume method. A simple in-house solver is developed before using open-source and commercial software.

Content

Numerical flow simulation (or Computational Fluid Dynamics) is an essential component of modern fluid mechanics. This course uses the student's existing knowledge in fluid mechanics and numerical methods as a basis for a global introduction to numerical flow simulation.
In the first part of the course, some numerical methods are presented for the discretization and resolution of the steady and unsteady Navier-Stokes equations and simpler advection-diffusion equations, in the framework of the finite volume method. A basic in-house code is developed with Matlab for 1D systems during the exercise sessions. Experience of a more complex, open-source CFD tool is gained for 2D problems with OpenFoam.
In the second part of the course, the overall simulation workflow is presented: pre-processing (geometry and mesh creation), computation (choice of physical models and numerical methods, flow calculation), validation, and post-processing (visualization). A state-of-the-art commercial software (Fluent) is used to study practical 2D/3D applications in the exercise sessions.

Keywords

Numerical simulation, Fluid mechanics

Learning Prerequisites

Required courses

- Incompressible fluid mechanics (ME-344)
- Numerical analysis (MATH-251)

Recommended courses

- Fluid flow (ME-271)
- Discretization methods in fluids (ME-371)

Important concepts to start the course

• Computer-aided design (CAD)

• Explain and apply the concepts of mass, energy, and momentum balance, E1

• Define, describe and apply the basic flow equations, such as the Navier-Stokes equations, AH14

• Understand the basics of computer programming; develop a (simple) structured software using a programming language / environment such as C, Fortran or Matlab, AH25

Learning Outcomes

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

• Describe the physical behaviour of a flow in scientific terms, AH1

• Link flow behaviour with non-dimensional parameters (e.g. Reynolds numbers), AH2

• Describe flow in simple geometries, such as over a flat plate, in a tube, or around a sphere or airfoil, AH9

• State the conserved quantities in a given flow and link them to a physical-mathematical description, AH13

• 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, AH18

• Assess / Evaluate numerical accuracy as a function of the choice of simulation parameters, AH20

• Analyze numerical solutions and identify any inconsistencies with respect to physical reality; understand and apply the concepts of verification and validation, AH21

• 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, AH26

• Choose the appropriate turbulence model for a given turbulent flow, AH27

Transversal skills

• Use both general and domain specific IT resources and tools

• Write a scientific or technical report.

• Plan and carry out activities in a way which makes optimal use of available time and other resources.

• Continue to work through difficulties or initial failure to find optimal solutions.

Teaching methods

Lectures, Practical computer exercises, Assignments (one individual homework and one group project).

Expected student activities

• Participation in classroom (practical exercises to learn methods and software).

• Assignments (written reports).

Assessment methods

Two written reports (one individual homework and one group project).

Supervision

Office hours	No
Assistants	Yes
Forum	No

Resources

Virtual desktop infrastructure (VDI)

Yes

Bibliography

Course material available on Moodle website.

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=126