ME-474 **Numerical flow simulation**

Boujo Edouard

Cursus	Sem.	Type
Computational science and Engineering	MA1, MA3	Opt.
Mechanical engineering minor	H	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**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

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

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 solver is developed with Matlab, and a commercial software is used for more complex problems.

Content

Numerical flow simulation (or Computational Fluid Dynamics, CFD) is an essential component of modern fluid mechanics research and engineering, complementary to theory and experiments. This course builds on the student's existing knowledge in fluid mechanics and numerical methods to introduce numerical flow simulation.

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 simple problems.

The overall modeling and simulation workflow is presented: pre-processing (mesh creation), computation (choice of physical models and numerical methods, flow calculation), validation, and post-processing (visualization and analysis). A state-of-the-art commercial software (Fluent) is used to study practical applications.

Keywords

Numerical simulation, Fluid mechanics

Learning Prerequisites

Required courses

- Fluid mechanics (ME-280)
- Numerical analysis (MATH-251)

Recommended courses

- 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

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

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Transversal skills

• Use both general and domain specific IT resources and tools

• 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.

• Write a scientific or technical report.

Teaching methods

Lectures, practical computer exercises, and homeworks / mini-project.

Expected student activities

- Attend class hours (theoretical lectures + practical exercises to learn the methods and the software).
- Finish exercises at home.
- Carry out the homeworks / mini-project and write reports.

Assessment methods

Written report (homeworks and mini-project).

Supervision

Office hours	No
Assistants	Yes
Forum	No

Resources

Virtual desktop infrastructure (VDI)

Yes

Bibliography

Course material available on Moodle website.

Moodle Link

- https://go.epfl.ch/ME-474