

ME-474

Numerical flow simulation

Sawley Mark

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

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|----------------------------|---------------------|
| Language of teaching | English |
| Credits | 5 |
| Session | Winter |
| Semester | Fall |
| Exam | During the semester |
| Workload | 150h |
| Weeks | 14 |
| Hours | 4 weekly |
| Lecture | 2 weekly |
| Exercises | 2 weekly |
| Number of positions | |

Summary

This course provides practical experience in the numerical simulation of fluid flows, comprising the three fundamental phases of pre-processing (geometry and mesh creation), computation (choice of physical models & numerical methods), and post-processing (quantitative analysis and visualization).

Content

Numerical flow simulation (or Computational Fluid Dynamics) is an essential component of modern fluid mechanics. The objective of this course is to use the student's existing knowledge in fluid mechanics and numerical methods as a basis for a global introduction to numerical flow simulation. An overview of the general theoretical concepts - such as mesh generation algorithms, turbulence modelling, resolution of the Navier-Stokes equations, scientific visualization - is provided in the lectures. State-of-the-art commercial and open-source software packages are used to study practical applications via worked flow cases and exercises. Course evaluation is based on written and oral presentations for three mini-projects performed during the semester.

Keywords

Numerical simulation, Fluid mechanics, Mesh generation, Scientific visualization

Learning Prerequisites**Required courses**

- Fluid mechanics
- Numerical analysis
- Discretization methods (e.g. finite differences, finite elements, finite volumes)

Important concepts to start the course

- Computer-aided design (CAD)

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
- Identify 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 , AH 23

- Choose the appropriate wall treatment model for a given turbulent flow , AH 26
- Choose the appropriate physical models and numerical methods to compute a physically-complex flow, such as a non-Newtonian, free surface or multiphase flow , AH 27
- Analyze numerical solutions and identify any inconsistencies with respect to physical reality; understand and apply the concepts of verification and validation , AH 29
- Perform numerical simulations 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.
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.
- Access and evaluate appropriate sources of information.
- Write a scientific or technical report.
- Assess one's own level of skill acquisition, and plan their on-going learning goals.

Teaching methods

Lectures, Worked flows examples, Practical exercises on workstations, Mini-projects.

The goal is to learn "hard skills" through the solving of challenging practical problems. However, significant importance will also be placed on "soft skills" such as writing reports, presenting orally, working in groups, and creativity in visual communication.

Expected student activities

- Participation in classroom (e.g. worked flow cases)
- Practical exercises (for apprenticeship of methods and software)
- Mini-projects in groups (including written reports and oral presentation)

Assessment methods

Three mini-project reports (75%), one mini-project oral presentation (20%), self assessment (5%)

Supervision

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| Office hours | No |
| Assistants | Yes |
| Forum | No |

Resources

Bibliography

Course material is available on Moodle web site. Various reference texts

Moodle Link

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