ME-444

Hydrodynamics

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

Language of teaching	English
Credits	5
Session	Summer
Semester	Spring
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Nondimensionalized Navier-Stokes equations result in a great variety of models (Stokes, Lubrification, Euler, Potential) depending on the Reynolds number. The concept of boundary layer enables us then to identify the different components of the hydrodynamic drag.

Content

The objective of this class is to describe and understand hydrodynamic flows by means of physical modeling. With help of dimensional analysis of the Navier-Stokes equations, several fluid models are introduced depending on the dominant physical effects: hydrostatics, capillarity, dissipation or inertia. This approach allows to describe important concepts like lift or wave dispersion and naturally leads to the concept of boundary layer so as to understand the appearance of drag,

Keywords

Waves, drag, lift, lubrication, boundary layer

Learning Prerequisites

Recommended courses

Incompressible fluid dynamics
fluid flows

Learning Outcomes

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

- Explain in scientific terms the basic concepts of continuum mechanics (e.g. kinematics, dynamics, conservation equations, Eulerian/Lagrangian approach, stress and strain tensors, constitutive laws, linear elasticity, Newtonian fluid) and apply them to model and analytically resolve simple problems, AH42
- Link flow behaviour with non-dimensional parameters (e.g. Reynolds and Mach numbers), AH2
- Resolve analytically or numerically the potential flow around an airfoil, AH25
- Describe flow in simple geometries, such as over a flat plate, in a tube, or around a sphere or airfoil, AH11
- State the conserved quantities in a given flow and link them to a physical-mathematical description, AH16
- Define, describe and apply the basic flow equations, such as the Navier-Stokes equations, AH17
- Describe simplified governing equations, such as the Bernoulli or potential equations, their domain of validity and apply them in appropriate situations, AH19
- Obtain by an order of magnitude analysis, the simplified equations describing lubrication and boundary layers, AH22
- Describe in detail the physical phenomena associated with the interaction of a flow with a solid wall (as a function of

its characteristics, e.g. roughness), AH5

• Describe in detail the physical phenomena associated with the interaction of a flow with a solid wall (as a function of its characteristics, e.g. roughness), AH5

• Apply by an order of magnitude analysis, the simplified equations describing lubrication and boundary layers, AH17

• Describe simplified governing equations, such as the Bernoulli or potential equations, their domain of validity and apply them in appropriate situations, AH15

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

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

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

• Solve analytically or numerically the potential flow around an airfoil, AH19

• Explain in scientific terms the basic concepts of continuum mechanics (e.g. kinematics, dynamics, conservation equations, Eulerian/Lagrangian approach, stress and strain tensors, constitutive laws, linear elasticity, Newtonian fluid) and apply them to model and analytically resolve simple problems.

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

Transversal skills

• Summarize an article or a technical report.

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

Teaching methods

Lectures and exercise sessions

Assessment methods

written exam

Supervision

Office hours	No
Assistants	Yes
Forum	No

Resources

Bibliography

Physical Hydrodynamics, Guyon, Hulin, Petit & Mitescu, Oxford, 2001.

Ressources en bibliothèque

• Hydrodynamique Physique / Guyon

Moodle Link

• http://moodle.epfl.ch/course/view.php?id=5161