2EL1420 – Fluid Mechanics

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Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00
Elective Category : Engineering Sciences
Advanced level : Yes

Description

The Fluid Mechanics course extends the fundamental notions, equations, and skills previously established during the course *Sciences des Transferts* on transport phenomena to a mastery of the various complexities of fluid flows, their dynamics, and systems whose properties are governed by fluid mechanics. The course allows for reaching a confirmed level in this discipline and the corresponding applications before considering more advanced and specialized studies. The course and practice sessions take into account the recent evolutions of the field by combining experimental, numerical, and theoretical approaches to train to engineer practices and future stakes (data analysis, modeling, simulations, measurements).

The course consists of three blocks. The first one deepens the fundamental notions through theoretical tools, processing, and analysis of experimental and numerical data. A second block is dedicated to the analysis of compressible flows in different regimes (subsonic, supersonic, shock waves), thus allowing to address a vast field of applications previously out of reach when considering incompressible flows. Finally, students are invited to choose the theme of their third block in order to briefly open to a specialization among Aerodynamics, Meteorological and climatic flows, Aeronautical and space propulsion, Energy systems, Environment, Hypersonics ...

Quarter number

SG6

Prerequisites (in terms of CS courses)

The course follows a previous one entitled *Sciences des Transferts / Transport Phenomena*. Students enrolled in this course must already be familiar with fundamental concepts and skills in fluid mechanics:

- Dimensional analysis
- Local and macroscopic balance equations for mass, species, momentum and energy
- Evolution of different fields (velocity, pressure, temperature) and their interactions
- Determination of stresses, forces, powers, efficiencies, head losses
- Boundary layer

Syllabus

Block #1: Advanced Fluid Mechanics (4 sessions)

- Session 1: Fundamental equations and potential flows
- Session 2: Analytical solutions et exact profile in boundary layers
- Session 3: Macroscopic balances and jump conditions through interfaces
- Session 4: Instabilities and Turbulence

Block #2: Compressible flows (4 sessions)

- Session 5: Gas dynamics – Isentropic flows
- Session 6: Critical conditions and isentropic efficiencies
- Session 7: Shock waves
- Session 8: Oblique shock wave and nozzle flows

Block #3: Thematic specialization (three sessions)

- Choice between different themes such as Aerodynamics, Meteorological and climatic flows, Aeronautical and space propulsion, Hypersonics, Energy systems, ...

Class components (lecture, labs, etc.)
11-course sessions: 3h00 each (1h30 of lecture followed by 1h30 of practice for sessions in blocks 1 and 2) :

- 8 lectures,
- 8 problem-solving workshop sessions.
- Continuous assessment with a knowledge test at the 4th and 5th session,
- 3 sessions in thematic blocks
- a final written test lasting 2 hours.
- preparation of a poster by groups of students for the evaluation of the thematic blocks

Grading

3 assessments through the different blocks:
Block 1 (20%) : tests (2 x 15 min.) of knowledge
The purpose of the knowledge tests during sessions n°4 and n°5 is to verify the notions acquired during the first block of the course. The student obtains a **CA grade** out of 20. Attendance to these tests is mandatory.
Block 2 (50%): supervised written test during the last class period
The final written test lasts 2 hours. In absolute terms, all the elements of the course outside the thematic block are included in the program. In practice, the subject will be mainly related to the content of block n°2 linked to compressible flows. The test is carried out with any authorized written document. The student obtains a **CF grade** out of 20.
Block 3 (30%) : preparation of a poster
The evaluation of the thematic block concerns a specific project started during the session on a technical and scientific subject related to the studied theme. The approach and the results of the project are reported through the preparation of a poster. The student obtains a **CB grade** out of 20 based on four criteria:

- CB.1: Form, clarity and structure
- CB.2 : Poster understandable for a person outside the work
- CB.3: Quality of the study
- CB.4: Importance of the personal work

The final score is the rounded score obtained after applying the formula:
NF = 0.5 x CF + 0.3 x CB + 0.2 x CA

Learning outcomes covered on the course

At the end of the course, the student will be able to:

- Model complex systems, a necessary step to their conception and optimization:
    - Make approximations et estimations,
    - Simplify an apparently complex system
    - Use fundamental balances to solve practical problems
- Characterize a system involving fluid flows thanks to several perspectives: simplified analytical solutions, results from numerical simulations, experimental data.
- Apply these skills to complex flow (unsteady, compressible)

- Face another disciplinary or application field related to fluid mechanics to show a rather autonomous adaptation to a new context

Description of the skills acquired at the end of the course

Core skills in CentraSupélec curriculum:

The course allows the students to validate the C1, C2 and C7 skills in the engineering curriculum.
C1 is validated if CF >=10.
C2 is validated if NF>=10 and CB >= 12.
C7 is validated if 0.5 x (CB.1 + CB.2) >= 14.