Course guide
205237 - AFM - Advanced Fluid Mechanics

Last modified: 02/04/2024

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 729 - MF - Department of Fluid Mechanics.

Degree: BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Optional subject).
BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Robert Castilla

Others:

PRIOR SKILLS

It is essential to have studied Fluid Mechanics.
It is advisable to have notions of programming.

TEACHING METHODOLOGY

This course is developed in the form of pills with advanced topics in Fluid Mechanics, independent of each other. The methodology is with Jupyter Notebooks, made with Python. No prior knowledge of Python is required, but basic knowledge of high-level programming (Matlab, Maple, etc ...) is required.
There are 6 pills, or blocks, of 5 teaching hours each. The first is an introductory block on Python and Jupyter Notebooks. The rest are the blocks described in the content. Notebooks are interactive, and students can download them and experiment with calculations, codes, data, ...
The work developed in class, discussions, exercises, deliveries, are done in groups of 2 or 3 people.

LEARNING OBJECTIVES OF THE SUBJECT

The objectives are oriented both to Fluid Mechanics and to the use of advanced tools for solving associated problems.
The main objective of the course is to provide the student with the basic knowledge necessary to be able to solve complex problems in Fluid Mechanics with the help of Python and Jupyter Notebooks.
The student will also learn to write interactive documents where he will describe his work with:
- Solve differential equations
- Statistical data processing
- Modeling of rheological behavior based on experimental data
- Solve nonlinear equations with numerical methods
- Creation of functions to make calculations with complex flows (boundary layer, compressible flow, ...)

STUDY LOAD

Type	Hours	Percentage
Hours large group	30,0	40.00
Self study	45,0	60.00

Total learning time: 75 h

CONTENTS

Module 0: Introduction to scientific computation with Python and Jupyter Notebooks

Description:
0.1 Numpy
0.2 Sympy
0.3 Pandas
0.4 Data fitting

Related activities:
Assignment 0

Full-or-part-time: 5h
Theory classes: 5h

Module 1: Microflows. Lubrication and capilarity

Description:
1.1 Introduction
1.2 Shear-Driven flows
1.3 Pressure-Driven flows
1.4 Surface-Tension Driven flows

Related activities:
Assignment 1

Full-or-part-time: 8h
Theory classes: 5h
Self study : 3h

Module 2: Rheology

Description:
2.1 Classification of fluids
2.2 Generalised Newtonian Fluid
2.3 Viscoelastic fluids

Related activities:
Assignment 2

Full-or-part-time: 8h
Theory classes: 5h
Self study : 3h

Module 3: Turbulence

Description:
3.1 Statistical description of turbulence
3.2 Scales of Turbulent flow
3.3 Wall flows

Related activities:
Assignment 3

Full-or-part-time: 8h
Theory classes: 5h
Self study : 3h

Module 4: Boundary Layer

Description:
4.1 Laminar boundary layer
4.2 Turbulent boundary layer
4.3 Control of boundary layer

Related activities:
Assignment 4

Full-or-part-time: 8h
Theory classes: 5h
Self study : 3h

Module 5: Compressible Flow

Description:
5.1 Acoustics and velocity of sound
5.2 Isentropic flow
5.3 Normal shock waves
5.4 Oblique shock wave and expansion waves
5.5 Prandtl-Meyer expansion fan

Related activities:
Assignment 5

Full-or-part-time: 8h
Theory classes: 5h
Self study : 3h

GRADING SYSTEM

The final grade is the average of the grades of the 5 deliverables per group.

BIBLIOGRAPHY

Basic:

- Kundu, Pijush K.; Cohen, Ira M.; Dowling, David R. Fluid mechanics [on line]. 5th ed. Amsterdam: Elsevier Academic Press, cop. 2012 [Consultation: 22/06/2022]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780123821003/fluid-mechanics. ISBN 9780123821003.
- Rudyak, Valery Ya.; Aniskin, Vladimir M.; Maslov, Anatoly A.; Minakov, Andrey V.; Mironov, Sergey G. Micro-and nanoflows : modeling and experiments [on line]. Cham, Switzerland: Springer, 2018 [Consultation: 03/02/2021]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5356269. ISBN 9783319755236.
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- Irgens, Fridtjov. Rheology and non-newtonian fluids [on line]. New York: Springer International Publishing, 2014 [Consultation: 03/10/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-319-01053-3. ISBN 9783319010526.
- Pope, Stephen B. Turbulent flows. Cambridge [etc.]: Cambridge University Press, 2000. ISBN 0521591252.
- Song, Hongqing. Engineering fluid mechanics. Beijing, China: Metallurgical Industry Press, 2018. ISBN 9789811343490.

Complementary:

- Schlichting, Herrmann; Gersten, Klaus. Boundary-layer theory [on line]. 9th ed. Berlin [etc.]: Springer-Verlag, 2017 [Consultation: 02/11/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-662-52919-5. ISBN 9783662570951.
- Johansson, Robert. Numerical Python: scientific computing and data science applications with Numpy, SciPy and Matplotlib. 2nd ed. New York: Apress, 2019. ISBN 9781484242452.

RESOURCES

Other resources:

https://github.com/rclUPC/AdvancedFluidMechanics />https://github.com/jupyter/jupyter/wiki