Course guide
220124 - FDTV - Fluid Dynamic Technologies in Vehicles

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 INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Optional subject).

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

LECTURER

Coordinating lecturer: GUSTAVO RAUSH ALVIACH

Others: Mercè García Vílchez

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. An understanding of, and skills for, the calculation, design and testing of machines.
2. An understanding of the basic principles of fluid mechanics and their application in solving engineering problems. The ability to calculate pipes, channels and fluid systems.
3. Applied knowledge of the fundamentals of fluid-mechanics systems and machines.

TEACHING METHODOLOGY

The course is divided into parts:

Theory classes
Practical classes
Self-study for doing exercises and activities.
In the theory classes, teachers will introduce the theoretical basis of the concepts, methods and results and illustrate them with examples appropriate to facilitate their understanding.
In the practical classes (in the classroom), teachers guide students in applying theoretical concepts to solve problems, always using critical reasoning. We propose that students solve exercises in and outside the classroom, to promote contact and use the basic tools needed to solve problems.
Students, independently, need to work on the materials provided by teachers and the outcomes of the sessions of exercises/problems, in order to fix and assimilate the concepts.
The teachers provide the curriculum and monitoring of activities (by ATENEA).

LEARNING OBJECTIVES OF THE SUBJECT

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

Level 1 and 2:
- Describe the role of fluids on the road of vehicles performance
- Explain the basic concepts associated with fluid technologies in road vehicles
Level 3
- Solve problems related to fluid flow in a road vehicle
- Use numerical and experimental tools for the analysis of fluid flows in a road vehicle

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 1: Introduction

Description:
1.1 Review of fundamentals of fluid dynamics concepts
1.2 Fluids in a vehicle
1.3 Aerodynamics of a vehicle

Related activities:
Activity 1: Introduction to the CFD: Aerodynamics of a wing profile. Forces measures
Activity 2: Control 1

Full-or-part-time: 14h
Theory classes: 4h
Self study : 10h

Module 2: Numerical techniques

Description:
2.1 Introduction to CFD
2.2 Main numerical methods
2.3 Modelling of turbulence
2.4 Meshing

Related activities:
Activity 2: Control 1
Activity 3: CFD Laboratory Session. Aerodynamics of a 3D Wing Profile and Cooking Wing System F1
Activity 5: Control 2
Activity 9: Session of Final Project Work.
Activity 10: Examination

Full-or-part-time: 34h
Theory classes: 14h
Self study : 20h

Module 3: Experimental techniques

Description:
3.1 Wind tunnel
3.2 Anemometry
3.3 PIV

Related activities:
Activity 4: Experimental Laboratory Session I: Measurement of aerodynamic forces
Activity 6: Experimental Laboratory Session II: Boundary Layer Measurements
Activity 7: Lab Session. Particle Image Velocimetry
Activity 8: Experimental Laboratory Session III: Viewing flow and video analysis
Activity 10: Examination

Full-or-part-time: 27h
Theory classes: 12h
Self study : 15h

ACTIVITIES

Activity 1: Introduction to the CFD: Aerodynamics of a wing profile. Forces measures

Description:
Installation of open source tools for CFD calculations. First simple examples of numerical calculations.

Specific objectives:
Introduction to aerodynamics concepts and notions of numerical simulations

Material:
Articles and class notes

Delivery:
Without delivery

Full-or-part-time: 10h
Theory classes: 4h
Self study: 6h

ACTIVITY 2: CONTROL 1

Description:
Control test made in theory class. Questions about material contributed from the theory and reference articles classes.

Material:
Notes and articles

Full-or-part-time: 5h
Theory classes: 1h
Self study: 4h

Activity 3: CFD Laboratory Session. Aerodynamics of a 3D Alar Profile and Cooking Wing System F1 car

Description:
Development of a real case of 3D geometry applied to a rear multi-elements wing profile of a Formula 1 or Formula Student Spain car.

Material:
CFD calculation code. Class notes. Web references.

Full-or-part-time: 12h
Theory classes: 4h
Self study: 8h

Activity 4: Experimental Laboratory Session I: Measurement of aerodynamic forces.

Description:
Measures of aerodynamic forces on a wing profile. Speed â□□â□□measures with dynamic and thermal probes. Use of aerodynamic balance.

Delivery:
Laboratory report

Full-or-part-time: 6h
Theory classes: 3h
Self study: 3h

Activity 5: Control 2

Description:
Control on the knowledges of CFD and the principles of experimental techniques developed in the first practices.

Material:
Notes and articles

Full-or-part-time: 4h
Theory classes: 1h
Self study: 3h

Activity 6: Experimental Laboratory Session II: Boundary Layer Measurements (Laminar and Turbulent)

Description:
Measures of the speed profiles of the boundary layer in different positions. Smooth plates are as well as rough plates.

Full-or-part-time: 6h
Theory classes: 3h
Self study: 3h

Activity 7: Lab Session. PARTICLE IMAGE VELOCIMETRY THEORY

Description:
Theory of one of the highly widespread flow display techniques in the visualizations and performance measures of competition cars.

Full-or-part-time: 5h
Theory classes: 3h
Self study: 2h

Activity 8: Experimental Laboratory Session III: Visualization flows and video analysis

Full-or-part-time: 7h
Theory classes: 3h
Self study: 4h

Activity 9: Final Project Work.

Description:
CFD Numerical characterization of a professor assigned vehicle or freely chosen by the student group.

Full-or-part-time: 9h
Theory classes: 6h
Self study: 3h

Activity 10: Examination

Description:
Theoretical examination of the general concepts learned throughout the course. System of Questions and Answers oriented to the parties of Numerical CFD and the experimental part.

Full-or-part-time: 11h
Theory classes: 2h
Self study: 9h

GRADING SYSTEM

The final grade depends on the following assessment criteria:

- Exam, weight: 30 %
- Final Project works, weight: 30 %
- Controls, weight: 20 %
- Laboratory, weight: 20 %

If the final exam is not exceeded with a note greater than 5 there is the possibility to carry an extraordinary test on. It will be developed within the calendar set by the school for cases of subjects that contemplate it.
The reconduction of the note is achieved through an extraordinary evaluation approved with a 5, and the final note will be determined by taking the highest rating between both evaluations.

BIBLIOGRAPHY

Basic:
- Katz, Joseph. Race car aerodynamics : designing for speed. Revised 2nd ed. Cambridge, MA: Bentley, 2006. ISBN 9780837601427.
- Hucho, W. H. (ed.); Ahmed, Syed R. [et al.]. Aerodynamics of road vehicles : from fluid mechanics to vehicle engineering. 4th ed. Warrendale: Society of Automotive Engineers, 1998. ISBN 0768000297.
- Barnard, R.H. Road vehicle aerodynamic design : an introduction. 2nd ed. Hertfordshire: Mechaero, 2001. ISBN 0954073401.
- Raffel, Markus; Willert, Christian E.; Scarano, Fulvio; Kähler, Christian J.; Wereley, Steve T.; Kompenhans, Jürgen. Particle image velocimetry: a practical guide [on line]. 2nd ed. Berlin [etc.]: Springer, 2007 [Consultation: 20/09/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-540-72308-0. ISBN 9783540723073.
- Barlow, Jewel B.; Rae, William H.; Alan Pope, Jr. Low-speed wind tunnel testing. 3rd ed. New York: Wiley, cop. 1999. ISBN 0471557749.

Complementary:
- Katz, Joseph; Plotkin, Allen. Low-speed aerodynamics. 2nd ed. Cambridge: Cambridge University Press, 2001. ISBN 0521665523.
- Benzing, Enrico. Dall'aerodinamica alla potenza in Formula 1: mezzo secolo di motori in analisi. Milano: Giorgio Nada, 2004. ISBN 9788879113182.
- Anderson, John David. Fundamentals of aerodynamics. 5th ed. New York: McGraw-Hill, 2011. ISBN 9780073398105.

RESOURCES

Other resources:
https://www.openfoam.org />https://www.openfoamwiki.net />https://www.bibliotecnica.upc.edu />https://www.cfd-online.com />https://www.wolfdynamics.com />