Last update: 23-04-2019

220020 - Fluid Mechanics

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 729 - MF - Department of Fluid Mechanics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN AEROSPACE VEHICLE ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 7,5 Teaching languages: Catalan, Spanish

Teaching staff

Coordinator: PEDRO JAVIER GAMEZ MONTERO - ROBERTO CASTILLA LOPEZ

Others: Raush Alviach, Gustavo Adolfo
Quintana Vallmitjana, Marc

Degree competences to which the subject contributes

Specific:

4. GrETA/GrEVA - An adequate understanding of the following, as applied to engineering: concepts and laws that govern the processes of energy transfer, the movement of fluids, the mechanisms of heat transfer and phase transition, and their role in analysis of the main aerospace propulsion systems.

Teaching methodology

The 3 theory classes per week, in large groups, are mainly instructed using the expository method, although small exercises, directly related to Activity 1, are included. In addition, some examples and particular applications are worked with a more active participation of students.
The applications classes, in medium groups, are problems from the collection available in ATENEA. Some of these problems are exposed by the lecturer in the classroom, but most are solved by the students in teams of 3, and delivered as homework and in ATENEA forums. The student's resolutions are accessible by the rest of the students.
The practical classes, in small groups, are done in the laboratory and in the computer classrooms. The work is developed in teams. The objective for the student is to be able to collect data, to process, analyze and draw conclusions, comparing the results with other reference, theoretical, numerical, or experimental results.

Learning objectives of the subject

At the end of the course, the student should be able to:
Levels 1 and 2 (knowledge and compression)
- Define the basic properties of fluids
- Discuss the fundamental concepts of phenomena associated with fluids.
Level 3 (application)
- To solve problems of Aeronautical Engineering related to the flow of Newtonian fluids
- Use the theoretical, experimental and numerical tools appropriate to each problem.

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Study load

Total learning time: 187h 30m	Hours large group:	47h	25.07%
	Hours medium group:	14h	7.47%
	Hours small group:	14h	7.47%
	Guided activities:	0h	0.00%
	Self study:	112h 30m	60.00%

Content

1 - Introduction and basic concepts

Learning time: 4h

Theory classes: 2h
Self study : 2h

Description:
1.1 Definition of fluid
1.2 Continuum hypothesis
1.3 Properties of fluids

Related activities:
Theoretical classes
Activity 1
Activity 3 (control 1)
Activity 4 (first mid-semester exam)

3 - Fluid Statics

Learning time: 10h 30m

Theory classes: 3h
Practical classes: 1h 30m
Self study : 6h

Description:
2.1 Surface, mass and linear forces
2.2 Fundamental equation for Fluid Statics
2.3 The atmosphere
2.4 Fluid statics force on a surface
2.5 Archimedes' principle
2.6 Second Law of Archimedes
2.7 Stability

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 3 (control 1)
Activity 4 (first mid-semester exam)

3 - Kinematics	Learning time: 3h 30m Theory classes: 1h Practical classes: 0h 30m Self study : 2h

Description:
3.1 Eulerian and Lagrangian description
3.2 Streamlines, pathlines and streaklines.
3.3 Substantial derivative
3.4 Circulation, flux and vorticity
3.5 Relative movement around a point

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 3 (control 1)
Activity 4 (first mid-semester exam)

4 - Dynamics and General Equations	Learning time: 45h Theory classes: 12h Practical classes: 5h Laboratory classes: 4h Self study : 24h

Description:
4.1 Conservatio equations
4.2 Reynolds' Transport Theorem
4.3 Differential and integral formulation
4.4 Conservation of mass
4.5 Conservation of momentum
4.6 Navier-Stokes Equations
4.7 Conservation of energy
4.8 Conservation of momentum of momentum
4.9. Bernuilli's Equation. Flowmeters.

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 3 (control 1)
Activity 4 (first mid-semester exam)
Activity 7 (Lab practice 1: Introduction to CFD)
Activity 8 (Lab practice 2: Flow in a fan)

5 - Dimensional analysis and theory of model	Learning time: 28h Theory classes: 7h Practical classes: 1h 30m Self study : 19h 30m

Description:
5.1 Bukingham's Pi Theorem
5.2 Basic dimensionless numbers
5.3 Nondimensionalization of equations
5.4 Similitude

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 3 (control 1)
Activity 4 (first mid-semester exam)
Activity 7 to 13 (Lab practice)

6 - Viscous flows	Learning time: 14h Theory classes: 3h Practical classes: 1h Laboratory classes: 2h Self study : 8h

Description:
6.1 Introduction to viscous flows
6.2 Equations an boundary conditions
6.3 Flow between two parallel plates
6.4 Continuity and Navier-Stokes equations in cylindrical coordinates
6.5 Hagen-Poiseuille flow
6.6 Flow between two concentric cylinders

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 5 (control 2)
Activity 6 (second mid-semester exam)
Activitat 9 (Lab practice 3: Viscous flow / CFD)

7 - Turbulent flows	Learning time: 6h Theory classes: 1h Laboratory classes: 2h Self study : 3h

Description:
7.1 Introduction to Turbulence. Reynolds Average.
7.2 Physical interpretation of Reynolds' tensor
7.3 Law of the wall and turbulent boundary layer

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 5 (control 2)
Activity 6 (second mid-semester exam)
Activity 10 (Lab practice: Measurement of turbulence with CTA)

8 - Boundary layer	Learning time: 10h 30m Theory classes: 3h Practical classes: 0h 30m Laboratory classes: 2h Self study : 5h

Description:
8.1 Introduction to boundary layer
8.2 Laminar boundary layer. Blasius' equation
8.3 Momentum-integral equations for the boundary layer
8.4 Turbulent boundary layer
8.5 Boundary layer with pressure gradient. Flow separation.

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 5 (control 2)
Activity 6 (second mid-semester exam)
Activitat 11 (Lab practice 3: Viscous flow / CFD)

9 - Ideal and potential flows	Learning time: 16h Theory classes: 4h Practical classes: 1h Self study : 11h

Description:
9.1 Euler's equations
9.2 Stream function
9.3 Vorticity equation
9.4 Elementary potential flows
9.5 Circulation

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 6 (second mid-semester exam)

10 - External Flow	Learning time: 11h Theory classes: 2h Practical classes: 1h Laboratory classes: 2h Self study : 6h

Description:
10.1 Introduction to Aerdynamics
10.2 Friction and pressure drag forces
10.3 Aerodynamic coefficients
10.4 Airfoils

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 6 (second mid-semester exam)
Activity 12 (Lab practice 6: Aerodynamics)

11 - Compressible flow	Learning time: 39h Theory classes: 9h Practical classes: 2h Laboratory classes: 2h Self study : 26h

Description:
11.1 Introduction to compressible flow. Review of thermodynamics
11.2 Speed of sound
11.3 Adiabatic flow
11.4 Sonic values
11.5 diffusers and injectors
11.6 Normal shock waves
11.7 Nozzles
11.8 Mach's conus
11.9 Oblique shock waves

Related activities:
Theretical and problem sessions
Activity 1
Activity 2
Activity 6 (second mid-semester exam)
Activity 13 (Lab practice 7: Compressible flow)

Planning of activities

1 - SIMPLE EXERCISES PRESENTED IN THE THEORETICAL DOCUMENTATION OF THE SUBJECT

Hours: 70h
Theory classes: 37h
Self study: 33h

Description:
Simple exercises of application of the theoretical concepts presented in the documentation. They are made and weekly delivered on the digital campus.

Support materials:
Notes of the subject in ATENEA

Descriptions of the assignments due and their relation to the assessment:
Exercises are weekly delivered. They can be handmade and scanned or photographed. The delivery is part of the 10% of the blobal mark ocrresponding to the class grade.

Specific objectives:
At the end of this activity the student should be able to:
- Apply the concepts acquired in the theoretical sessions to solve simple problems

2 - PROBLEMS

Hours: 45h 30m
Practical classes: 14h
Self study: 31h 30m

Description:
Problems solved in teams of 3 students. Problems are discussed in class.

Support materials:
Subject notes
Collection of problems

Specific objectives:
At the end of this activity the student should be able to:
- Find and analyze technical documentation in the biography and / or on Internet related to the proposed problems
- Work in teams and distribute tasks in order to efficiently solve problems.

4 - CONTROL 1

Hours: 4h
Theory classes: 1h
Self study: 3h

Description:
Test type control solved by couples in the classroom

Support materials:
A sheet with handwritten formulae.

Descriptions of the assignments due and their relation to the assessment:
The mark is part of the 10% of the global mark corresponding to controls grade.

Specific objectives:
At the end of this activity the student must be able to:
- Show the achievement of the specific objectives associated with contents 1, 2, 3 and first half of 4.

4 - FIRST MID-SEMESTER EXAM	Hours: 11h Theory classes: 3h Self study: 8h

Description:
Individual mid-semester exam

Support materials:
Formulae used in controls

Descriptions of the assignments due and their relation to the assessment:
The exam is the 30% of final course mark

Specific objectives:
At the end of this activity the student should be able to:
- Show the achievement of the specific objectives associated with contents 1, 2, 3, 4 and 5

5 - CONTROL 2	Hours: 4h Theory classes: 1h Self study: 3h

Description:
Test type control solved by couples in the classroom

Support materials:
A sheet with handwritten formulae.

Descriptions of the assignments due and their relation to the assessment:
The mark is part of the 10% of the global mark corresponding to controls grade.

Specific objectives:
At the end of this activity the student must be able to:
- Show the achievement of the specific objectives associated with contents 6, 7, 8 and first half of 8.

6 - SECOND MID-SEMESTER EXAM	Hours: 11h Theory classes: 3h Self study: 8h

Description:
Individual mid-semester exam. It includes an activity for recovery of activity 4 (firs mid-semester exam)

Support materials:
Handwritten formulae used in controls

Descriptions of the assignments due and their relation to the assessment:
The exam is the 40% of the course global grade.

Specific objectives:
At the end of this activity the student should be able to:
- Show the achievement of the specific objectives associated with content 6, 7, 8, 9, 10 and 11.

7 - LAB PRACTICE 1. INTRODUCTION TO CFD	Hours: 4h Laboratory classes: 2h Self study: 2h

Description:
Lab practice with a very basic introduction to CFD tools that will be used in computer practices

Support materials:
CFD software
Desktop in computer classroom
Subject notes
Lab practices guide.

Descriptions of the assignments due and their relation to the assessment:
Report by teams.
The correct delivery of the report is part of the 10% of the overall course grade, corresponding to the laboratory grade

Specific objectives:
At the end of this activity the student should be able to:
- Find information on the Internet, books, articles on numerical methods using CFD
- Describe in generic form what is a CFD program
- Perform a simulation with simple geometry, a laminar flow with standard contour conditions.
- Interpret the results obtained from a CFD simulation

8 - LAB PRACTICE 2. FLOW RATE MEASUREMENT IN A FAN	Hours: 4h Laboratory classes: 2h Self study: 2h

9 - LAB PRACTICE 3. VISCOUS FLOW	Hours: 4h Laboratory classes: 2h Self study: 2h

10 - LAB PRACTICE. MEASUREMENT OF TURBULENCE WITH CTA	Hours: 4h Laboratory classes: 2h Self study: 2h

Description:
Measurement of turbulent magnitudes with CTA (Constant Temperature Anemometry)

11 - LAB PRACTICE. BOUNDARY LAYER	Hours: 4h Laboratory classes: 2h Self study: 2h

12 - LABORATORY PRACTICE 6. EXTERNAL FLOW - AERODYNAMIC BALANCE	Hours: 4h Laboratory classes: 2h Self study: 2h

Description:
Aerodynamic coeffcients of a body are measured and compared with reference values.

13 - LABORATORY PRACTICE 7. COMPRESSIBLE FLOW	Hours: 4h Laboratory classes: 2h Self study: 2h

Description:
Practice with Computational Fluid Dynamics software. A compressible flow is simulated and the results are compared with the estimations calculated made in problem sessions

Support materials:
CFD software
Desktop in classroom
Subject notes
Guide of the practice in ATENEA

Descriptions of the assignments due and their relation to the assessment:
Report in a group of three students.
The correct delivery of the report is part of the 10% of the overall course grade, corresponding to the laboratory grade

Specific objectives:
At the end of this activity the student should be able to:
- Design a compressible flow simulation with a simple geometry.
- Interpret the results obtained from the simulation and compare them with the analytical results.

14 - ARTICLES READING	Hours: 6h Self study: 6h

Description:
The student has to read an article or chapter of a book, in English, Spanish or Catalan, and make a small report/summary.

Support materials:
Article

Descriptions of the assignments due and their relation to the assessment:
The assessment of the report is part of the 10% of the overall course mark, corresponding to the class grade.

Specific objectives:
At the end of this activity the student should be able to:
- Extract from a scientific paper on Fluid Mechanics the most significant features
- Criticize and comment on a scientific article on Fluid Mechanics

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Qualification system

1st mid-semester, weigth: 30%
2on mid-semestar weight: 40%
Class grade, weight: 10%
Control tests, weight: 10%
Lab practices, weight: 10%

In the case of unsatisfactory results in the first mid-semester, and whenever the grade is less than 5, the second mid-semester will be replaced by a final exam with the content of the whole subject. The final grade corresponding to the partial marks (70%) will be the highest value between the final exam and the weighting between the 1st mid-term and the second part in the final exam.

Regulations for carrying out activities

The controls are test type and they will be written in couples with an approximate duration of 30 minutes. Students can have a handmade collection of formulae.

The mid-semester exams ones consist of:
- Two problems. 2 hours duration. They may include evaluation of theoretical concepts. With formulae and calculator. Each problem is 50% of the total mid-semester mark.

The exams have be written with pen.

Theoretical tasks must be presented every week in ATENEA. They can be made by hand, scanned or photographed.
The problems must be presented in ATENEA, made with a word processor, with the format available in ATENEA, and always with pdf format.
The reports of the practices must be presented in ATENEA, made with a word processor, with the format available in ATENEA, and always with pdf format.

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Basic:

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Daily, James W. Dinámica de los fluidos: con aplicaciones en la ingeniería. México: Trillas, 1969.

Sánchez Nieto, Manuel M. Mecánica de fluidos general. Cartagena: Universidad Politécnica de Cartagena. Escuela Técnica Superior de Ingeniería Industrial, 2007. ISBN 9788495781796.

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López-Herrera Sánchez, José M. [et al.]. Mecánica de fluidos: problemas resueltos. Madrid: McGraw-Hill, 2005. ISBN 8448198891.

Complementary:

Barrero Ripoll, Antonio [et al.]. Fundamentos y aplicaciones de la mecánica de fluidos. Madrid: McGraw-Hill, 2005. ISBN 8448198905.

Batchelor, G.K. Introducción a la dinámica de fluidos. Madrid: Ministerio de Medio Ambiente. Dirección General del Instituto Nacional de Meteorología, 1997. ISBN 8483200155.

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Taylor, Travis S. Introduction to rocket science and engineering. Boca Raton: CRC Press, 2009. ISBN 9781420075281.

Others resources:

Notes and slides in Atenea

Hyperlink

www.efluids.com

Portal de recursos en internet sobre Mecánica de Fluids

www.cfd-online.com

Portal sobre Computational Fluid Dynamics

www.potto.org

Projecte per la publicació de material docent de forma oberta i gratuita. Llibre sobre Flux Compressible.