UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Course guide
220024 - AD - Aerodynamics

Last modified: 19/04/2023

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 220 - ETSEIAT - Terrassa School of Industrial and Aeronautical Engineering.

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

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: Ortega, Enrique

Others:

PRIOR SKILLS

This course requires background knowledge of fluid mechanics and basic concepts of thermodynamics and mechanics. It is also recommended that students have basic programming skills (high-level languages) and reading comprehension in English, as the literature for this subject comes mostly from sources in that language.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE22-GREVA. Adequate and applied knowledge in engineering: fundamentals of fluid mechanics describing flow in all regimes to determine pressure distributions and forces on aircraft. (Specific technology module: Aircraft)
CE23-GREVA. Adequate and applied knowledge in engineering: physical phenomena of flight, its qualities and control, aerodynamic and propulsive forces, performance, and stability. (Specific technology module: Aircraft)
CE22. GrETA - An adequate understanding of the following, as applied to engineering: physical phenomena of flight, flight qualities and control, aerodynamic and propulsive forces, performance and stability.
CE21-GRETA. GrETA - An adequate understanding of the following, as applied to engineering: the fundamentals of fluid mechanics describing flow in all regimes in order to determine the distributions of pressures and forces acting on aircraft.

TEACHING METHODOLOGY

During the course two weekly sessions will be held (2 hours each). Each session will be divided into a theoretical part, in which the contents of the subject will be developed, and a practical part, where application problems and doubts of the students will be solved. The percentage of time devoted to theory and problems in each session will be adjusted to the specific needs of the topics developed.

The course consists of 5 study modules. For each of them, students will have the respective class notes, a problems guide and a series of supervised learning activities aimed at complementing the topics developed. For each learning activity, the students will be given the reference material and a guide for its resolution.

Both the problems and the learning activities must be resolved autonomously. Doubts that may arise will be solved in class, as well as through the Atenea forum and during individualized tutoring hours. The first learning activity, which will consist of a review of previous knowledge, basic for the development of the subject, will be evaluated by means of a specific multiple-choice test. The other learning activities are likely to be evaluated in the partial and final exams. The problems will be evaluated in the partial and final exams, together with the theory developed in class.

The subject will be evaluated through a first placement exam (theoretical, multiple choice) and two written exams including both theory and application problems. In addition, two homework activities (to be developed in small groups) will be proposed. These will be also taken into account to compute the final grade of the course (see "Grading system").

LEARNING OBJECTIVES OF THE SUBJECT

The main objective of this course is to help students to acquire an adequate understanding of the fundamental concepts behind aerodynamic external flows, and develop their ability to analyze and solve aeronautics problems. The specific objectives of the course are the following:

- Analysis and prediction of aerodynamic performance of airfoils and wings using classical methods for incompressible and compressible flows.
- Analysis of the main aerodynamic characteristics of typical wing-body and wing-body-tail configurations.
- Introduction to simple numerical techniques for aerodynamic analysis and computational implementation. Application of the tools developed to solve typical airfoil problems.
- Development of a critical attitude to assess the extent and suitability of the different methods available for solving specific problems in aerodynamics.

In order to achieve the objectives listed above, the incompressible thin-airfoil theory will be studied first, and applications to the solution of typical airfoil aerodynamics problems will be carried out. For the analysis of three-dimensional wings and related problems the classical finite-wing theory will be used. It is expected that during the course students implement simple numerical applications to solve airfoils. Concerning compressible flows, the linearized theory for thin sections will be studied and aspects concerning the aerodynamic behavior of typical three-dimensional configurations in transonic and supersonic flows will be discussed.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	14,0	9.33
Self study	90,0	60.00
Hours large group	46,0	30.67

Total learning time: 150 h

CONTENTS

Module 1: Basic principles

Description:
Reiew of basic aspects of fluid mechanics. Aerodynamic forces and moments. Pressure distribution, center of pressure and aerodynamic center. Characteristics of airfoils.

Full-or-part-time: 22h
Theory classes: 8h
Practical classes: 2h
Self study : 12h

Module 2: Airfoils in ideal incompressible flow

Description:
Ideal lifting flows. Kutta condition. Thin-airfoil theory. Application to symmetric and cambered airfoils. Trailing-edge flaps. Applications and numerical solution. Aerodynamic characteristics of airfoils in real flows.

Full-or-part-time: 46h
Theory classes: 12h
Practical classes: 4h
Self study : 30h

Module 3: Finite wings in ideal incompressible flow

Description:
Vortex lines, Biot-Savart's law and Helmholtz's theorem. Prandtl's lifting line theory for wings with elliptic and arbitrary distribution of circulation. Basic and additional lift. Wing's pitching moment and aerodynamic center. Effects of taper ratio, twist and sweep.

Full-or-part-time: 44h
Theory classes: 10h
Practical classes: 4h
Self study : 30h

Module 4: Ideal compressible flow analysis

Description:
Main characteristics of compressible flows and basic types of discontinuities. Linearized potential theory for subsonic flows (small perturbations approach). Prandtl-Glauert and other compressiblity corrections. Critical Mach number. Characteristics of transonic flows around airfoils. Applications of the linearized theory to supersonic airfoils. Influence of wing's sweepback.

Full-or-part-time: 23h
Theory classes: 10h
Practical classes: 3h
Self study : 10h

Module 5: Fuselage, tail and wing-body-tail configurations

Description:
Basic aspects of the fuselage and tail aerodynamics. Wing-body-tail configurations, interference effects. Wing-body in compressible flow, transonic area rule.

Full-or-part-time: 15h
Theory classes: 6h
Practical classes: 1h
Self study : 8h

GRADING SYSTEM

The course will be graded according to:

NF = 0.1*T1 + 0.3*EX1 + 0.15*HW1 + 0.15*HW2 + 0.3*EX2

where NF is the final grade of the course, T1 is the grade of the placement test, EX1 is the grade of the first (mid-term) written exam and EX2 is the grade corresponding to the second (final) written exam. HW1 and HW2 are the grades obtained in the homework assignments.

The first placement test will assess theoretical background knowledge (supervised learning activity 1). The first and final written exams will evaluate both theoretical and practical (problem solving) aspects. Students having a mark below 5 in the mid-term exam may repeat that test on the date scheduled for the final exam (additional time will be provided for this purpose). The resulting final mark for the mid-term exam will be a weighted average between the original (0.15) and the second-chance examination (0.85). If the grade obtained is lower than that corresponding to the original exam, the latter is preserved.

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EXAMINATION RULES.

The written exams will be performed in an individual manner and no additional material is allowed for their solution to that provided by the professors. The homework activities will be performed in small groups to be composed at the beginning of the course.

BIBLIOGRAPHY

Basic:
- Anderson, J. D. Fundamentals of aerodynamics. 5th ed. New York: McGraw-Hill, 2011. ISBN 9780073398105.
- Kuethe, A. M.; Chow, C. Y. Foundations of aerodynamics: bases of aerodynamic design. 5th ed. New York: John Wiley & Sons, 1998. ISBN 0471129194.

Complementary:
- Schlichting, H.T.; Truckenbrodt, E. Aerodynamics of the airplane. New York: McGraw-Hill, 1979. ISBN 9780070553415.
- MacCormick, Barnes W. Aerodynamics, aeronautics and flight mechanics. 2nd ed. New York: John Wiley & Sons, 1995. ISBN 0471575062.
- Karamcheti, Krishnamurty. Principles of ideal-fluid aerodynamics. Huntington, New York: Robert E. Krieger Publishing, 1980. ISBN 9780898741131.
- Abbott, Ira H.; Doenhoff, Albert E. von. Theory of wing sections: including a summary of airfoil data. New York: Dover, 1959. ISBN 0486605868.
- Meseguer, J.; Sanz, A. Aerodinámica básica. 2ª ed. Madrid: Garceta, 2011. ISBN 9788492812714.
- Katz, Joseph; Plotkin, Allen. Low-speed aerodynamics. 2nd ed. Cambridge: Cambridge University Press, 2001. ISBN 0521665523.