UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Last update: 23-07-2019

220024 - Aerodynamics

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering

Teaching unit: 220 - ETSEIAT - Terrassa School of Industrial and Aeronautical Engineering

Academic year: 2019

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

ECTS credits: 6 Teaching languages: Spanish

Teaching staff

Coordinator: Ortega, Enrique

Others: A definir

Opening hours

Timetable: To be scheduled at the beginning of the course

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:

TA/VA-CE10. GrETA/GrEVA - An understanding of how aerodynamic forces determine flight dynamics and the role of the different variables involved in flight.
TA/VA-CE20. GrETA/GrEVA - Adapted and applied to engineering knowledge: fracture mechanics and continuum approaches
dynamic fatigue of structural instability and aeroelasticity.

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 typical application problems will be solved in order to provide students with a better understanding of the theoretical contents. The percentage of time devoted to theory and problem solving in each session will be adjusted to the specific needs of each topic.

The course consists of 4 modules of study. For each module, students will have to resolve practical problems in an autonomous manner. The doubts that may arise in their solution will be fixed during the practical part of the classes, as well as during the hours of individualized tutoring.

The course will be graded by means of a theoretical test (performed during the first weeks of the course) and two written exams including both theoretical and practical parts. In addition, a homework activity (to be developed in small groups) will be proposed. The test and the homework activity will be also taken into account to compute the final grade of the course (see "Sistema de Calificación").

Last update: 23-07-2019

220024 - Aerodynamics

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

Total learning time: 150h	Hours large group:	46h	30.67%
	Hours medium group:	14h	9.33%
	Hours small group:	0h	0.00%
	Guided activities:	0h	0.00%
	Self study:	90h	60.00%

220024 - Aerodynamics

Content

Module 1: Basic principles

Learning time: 19h

Theory classes: 5h
Practical classes: 1h
Self study : 13h

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

Module 2: Airfoils in ideal incompressible flow

Learning time: 53h

Theory classes: 13h
Practical classes: 6h
Self study : 34h

Description:
Principles of irrotational flow; circulation; Kelvin's theorem. Velocity potential and stream function. 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.

Module 3: Finite wing in ideal incompressible flow

Learning time: 52h

Theory classes: 19h
Practical classes: 4h
Self study : 29h

Description:
Three-dimensional characteristics of the flow around wings and induced drag concept. Biot-Savart's law and Helmholtz's theorem. Prandtl's lifting line theory for elliptic and arbitrary circulation wings. Influence of twist. Basic and additional lift. Effects of sweep and trailing-edge flaps. The concept of mean aerodynamic chord. Aerodynamic characteristics of wing-body and wing-body-tail configurations.

Module 4: Ideal compressible flow analysis

Learning time: 26h

Theory classes: 9h
Practical classes: 3h
Self study : 14h

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. Wing-body configurations in compressible flows. Influence of sweepback and area rules.

220024 - Aerodynamics

Qualification system

The course will be graded according to

NF = 0.15*LT + 0.3*EX1 + 0.15*HW + 0.40*N_EX2

where NF is the final grade of the course, LT is the grade obtained in the theoretical test, EX1 is the grade of the first (mid-term) written exam, EX2 is the grade corresponding to the second (final) written exam, and HW1 is the grade obtained in the homework assignment.

Both theoretical and practical (problem solving) aspects will be evaluated in the first and final written exams. 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.

Regulations for carrying out activities

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.
The theoretical test will be held in class time and the date will be scheduled 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:

MacCormick, Barnes W. Aerodynamics, aeronautics and flight mechanics. 2nd ed. New York: John Wiley & Sons, 1995. ISBN 0471575062.

Schlichting, H.T.; Truckenbrodt, E. Aerodynamics of the airplane. New York: McGraw-Hill, 1979. ISBN 9780070553415.

Katz, Joseph; Plotkin, Allen. Low-speed aerodynamics. 2nd ed. Cambridge: Cambridge University Press, 2001. ISBN 0521665523.

Meseguer, J.; Sanz, A. Aerodinámica básica. 2ª ed. Madrid: Garceta, 2011. ISBN 9788492812714.

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.