Course guide
300276 - AER - Aerodynamics

Last modified: 12/06/2023

Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING (Syllabus 2015). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 4.5 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: Definit a la infoweb de l'assignatura.

Others: Definit a la infoweb de l'assignatura.

REQUIREMENTS

Prerequisites: THERMODYNAMICS, FLUID MECHANICS

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
3. CE 19 AERO. Conocimiento aplicado de: la ciencia y tecnología de los materiales; mecánica y termodinámica; mecánica de fluidos; aerodinámica y mecánica del vuelo; sistemas de navegación y circulación aérea; tecnología aeroespacial; teoría de estructuras; transporte aéreo; economía y producción; proyectos; impacto ambiental. (CIN/308/2009, BOE 18.2.2009)
2. CE 18 AERO. Conocimiento adecuado y aplicado a la Ingeniería de: Los fundamentos de la mecánica de fluidos; los principios básicos del control y la automatización del vuelo; las principales características y propiedades físicas y mecánicas de los materiales. (CIN/308/2009, BOE 18.2.2009)

Generical:
CG2. (ENG) CG2 - Planificación, redacción, dirección y gestión de proyectos, cálculo y fabricación en el ámbito de la ingeniería aeronáutica que tengan por objeto, de acuerdo con los conocimientos adquiridos, los vehículos aeroespaciales, los sistemas de propulsión aeroespacial, los materiales aeroespaciales, las infraestructuras aeroportuarias, las infraestructuras de aeronavegación y cualquier sistema de gestión del espacio, del trafico y del transporte aéreo.
CG1. (ENG) CG1 - Capacidad para el diseño, desarrollo y gestión en el ámbito de la ingeniería aeronáutica que tengan por objeto, de acuerdo con los conocimientos adquiridos, los vehículos aeroespaciales, los sistemas de propulsión aeroespacial, los materiales aeroespaciales, las infraestructuras aeroportuarias, las infraestructuras de aeronavegación y cualquier sistema de gestión del espacio, del trafico y del transporte aéreo.

Transversal:
5. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
6. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
8. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
9. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.
06 URI N2. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.
07 AAT N2. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

Basic:
CB2. (ENG) CB2 - Que los estudiantes sepan aplicar sus conocimientos a su trabajo o vocación de una forma profesional y posean las competencias que suelen demostrarse por medio de la elaboración y defensa de argumentos y la resolución de problemas dentro de su área de estudio
CB5. (ENG) CB5 - Que los estudiantes hayan desarrollado aquellas habilidades de aprendizaje necesarias para emprender estudios posteriores con un alto grado de autonomíA

TEACHING METHODOLOGY

LEARNING OBJECTIVES OF THE SUBJECT

- Identificar els règims de compressibilitat i turbulència de fluxos aerodinàmics i les equacions associades a una situació de vol qualsevol.
- Identificar l'origen de les forces aerodinàmiques resultants de fluxos externs.
- Resoldre analíticament problemes simples d'aerodinàmica.
- Interpretar correctament resultats experimentals en aerodinàmica.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	15,0	13.33
Guided activities	10,5	9.33
Hours large group	24,0	21.33
Self study	63,0	56.00

Total learning time: 112.5 h

CONTENTS

Introduction to aerodynamics

Description:
- Introduction
- General equations of fluid motion: Navier-Stokes equations
- Continuity equation
- Newton’s 2nd Law
- Energy equation
- Simplifications
- Euler, Euler-Bernoulli and Bernoulli equations
- Differential equation for the velocity potential

Full-or-part-time: 11h
Theory classes: 4h
Laboratory classes: 1h
Self study : 6h

Inviscid aerodynamics

Description:
PART 1:
- Introduction
- Aerodynamic forces acting on an airfoil in stationary 2D potential flow:
- D'Alembert's paradox
- Kutta-Yukovski theorem
- Viscosity effects
- Sharp trailing edge
- Hypothesis of Kutta
- Generation of circulation
- Lift, drag & pitching moment coefficient

PART 2:
- Introduction
- Mathematical approach
- Linearization
- Symmetric problem
- Lifting/camber problem

PART 3:
- Introduction
- Lanchester-Prandtl wing theory:
- Wing global lift
- Wing global lift coefficient
- Induced drag

Full-or-part-time: 50h
Theory classes: 18h
Laboratory classes: 2h
Self study : 30h

Viscous aerodynamics: Boundary layer

Description:
Part 1: Introduction
Viscous effects in aerodynamics
Drag Coefficient of flow around various objects
Shortcomings of potential flow theory
Part 2: Laminar Boundary Layer
Boundary Layer Hypothesis
Equations
Solution methods
Part 3: Turbulent Boundary Layer
Transition & turbulent flows
Equations
Solution methods
Turbulent boundary layer structure
Part 4: Extensions to boundary layer theory
Compressible boundary layer
3-dimensional boundary layer
Laminar-turbulent transition

Full-or-part-time: 45h
Theory classes: 16h
Laboratory classes: 2h
Self study : 27h

Evaluation activities

Description:
Exams, tests, graded exercises and other evaluation activities

Full-or-part-time: 6h 30m
Laboratory classes: 6h 30m

GRADING SYSTEM

BIBLIOGRAPHY

Basic:
- Anderson, John David. Fundamentals of aerodynamics [on line]. 5th ed. New York: McGraw-Hill, cop. 2011 [Consultation: 10/10/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5662650. ISBN 9780073398105.
- White, Frank M. Mecánica de fluidos [on line]. 6ª ed. Madrid [etc.]: McGraw-Hill, cop. 2008 [Consultation: 15/04/2020]. Available on: http://www.ingebook.com/ib/NPcd/IB_BooksVis?cod_primaria=1000187&codigo_libro=4144. ISBN 9788448166038.
- Oertel, Herbert. Prandtl-Essentials of Fluid Mechanics [on line]. New York, NY: Springer New York, 2010 [Consultation: 15/04/2020]. Available on: http://dx.doi.org/10.1007/978-1-4419-1564-1. ISBN 9781441915641.

Complementary:
- de Iaco Veris, Alessandro. Practical Astrodynamics [on line]. First edition. Cham: Springer, [2017] [Consultation: 15/05/2020]. Available on: https://doi.org/10.1007/978-3-319-62220-0. ISBN 9783319622194.
- Schlichting (Deceased), Hermann; Gersten, Klaus. Boundary-Layer Theory [on line]. 9th ed. 2017. Berlin, Heidelberg: Springer Berlin Heidelberg : Imprint: Springer, 2017 [Consultation: 15/04/2020]. Available on: http://dx.doi.org/10.1007/978-3-662-52919-5. ISBN 9783662529195.
- White, Frank M. Viscous fluid flow. 3rd ed. New York [etc.]: McGraw-Hill, 2006. ISBN 007124493X.
- Cebeci, Tuncer; Cousteix, Jean. Modeling and computation of boundary-layer flows : laminar, turbulent and transitional boundary layers in incompressible and compressible flows. 2nd rev. and ext. ed. Long Beach, California : Berlin: Horizons ; Springer, 2005. ISBN 354024459X.

RESOURCES

Other resources:
- Presentacions de classe
- Col·lecció de problemes
- Material multimèdia
- Guió de pràctiques de laboratori