UNIVERSIDAD DE CASTILLA - LA MANCHA

GUÍA DOCENTE

1. General information

Course:	AERODYNAMICS	**Code:**	56722
Type:	CORE COURSE	**ECTS credits:**	6
Degree:	403 - UNDERGRADUATE DEGREE PROGRAMME IN AEROSPACE ENGINEERING	**Academic year:**	2023-24
Center:	303 - E.DE INGENIERÍA INDUSTRIAL Y AEROESPOACIAL DE TOLEDO	**Group(s):**	40
Year:	3	**Duration:**	First semester
Main language:	Spanish	**Second language:**	English
Use of additional languages:		**English Friendly:**	Y
Web site:		**Bilingual:**	N

Lecturer: **FRANCISCO COBOS CAMPOS** - Group(s): **40**

Building/Office	Department	Phone number	Email	Office hours
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2. Pre-Requisites

Before study this subject, it is convenient to have passed the subjects of Algebra, Calculus I and II, Physics I and II, Mathematical Methods, Technical Thermodynamics and Heat Transfer and Fluid Mechanics.

3. Justification in the curriculum, relation to other subjects and to the profession

It is a relevant subject in the aeronautical field. Its location and specialized orientation is based on the fact that the specific technology module in aerospace equipment and materials of the Degree in Aerospace Engineering includes competencies related to aerodynamics that can only be covered with specific subjects with such orientation.

4. Degree competences achieved in this course

Course competences

Code	Description
CA01	Ability to carry out bibliographic searches, use databases and other sources of information for its application in tasks related to Technical Aeronautical Engineering.
CA02	Ability to efficiently design experimentation procedures, interpret the data obtained and specify valid conclusions in the field of Aeronautical Technical Engineering.
CA03	Ability to autonomously select and carry out the appropriate experimental procedure, operating the equipment correctly, in the analysis of phenomena within the scope of Engineering.
CA04	Ability to select advanced tools and techniques and their application in the field of Aeronautical Technical Engineering.
CA05	Knowledge of the methods, techniques and tools as well as their limitations in the application for the resolution of problems typical of Aeronautical Technical Engineering.
CA06	Ability to identify and assess the effects of any solution in the field of Aeronautical Technical Engineering within a broad and global context and the ability to interrelate the solution to an engineering problem with other variables beyond the technological field, which must be considered.
CB02	Apply their knowledge to their job or vocation in a professional manner and show that they have the competences to construct and justify arguments and solve problems within their subject area.
CB03	Be able to gather and process relevant information (usually within their subject area) to give opinions, including reflections on relevant social, scientific or ethical issues.
CB04	Transmit information, ideas, problems and solutions for both specialist and non-specialist audiences.
CB05	Have developed the necessary learning abilities to carry on studying autonomously
CE02	Understanding and command of the basic concepts of the general laws of mechanics, thermodynamics, fields and waves and electromagnetism and their application to solve engineering problems.
CE08	knowledge of the thermodynamic cycles that generate mechanical power and thrust.
CE10	Knowledge of flight dynamics based on aerodynamic forces and the role of the different variables involved in the phenomenon of flight
CE15	Knowledge applied to Engineering of: The principles of the mechanics of the continuous medium and the techniques for calculating its response.
CE16	Knowledge applied to Engineering of: The concepts and laws that govern the processes of energy transfer, the movement of fluids, the mechanisms of heat transmission and the change of matter and their role in the analysis of the main systems aerospace propulsion.
CE18	Knowledge applied to Engineering of: The fundamentals of fluid mechanics; the basic principles of flight control and automation; the main characteristics and physical and mechanical properties of materials.
CE19	Applied knowledge of: materials science and technology; mechanics and thermodynamics; fluid mechanics; aerodynamics and mechanics of flight; air traffic and navigation systems; aerospace technology; structure theory; air Transport; economy and production; Projects; environmental impact.
CE21	Knowledge applied to Engineering of: The fundamentals of fluid mechanics that describe flow in any regime and determine pressure distributions and aerodynamic forces.
	Knowledge applied to Engineering of: The methods of calculation and development of defense materials and systems; the management of experimental techniques, equipment and measuring instruments typical of the discipline; the numerical simulation of

CE25	the most significant physical-mathematical processes; inspection, quality control and fault detection techniques; the most appropriate repair methods and techniques.
CE26	Applied knowledge of: aerodynamics; flight mechanics, air defense engineering (ballistics, missiles and air systems), space propulsion, materials science and technology, structural theory.
CG01	Capacity for the design, development and management in the field of aeronautical engineering that have as their object, in accordance with the knowledge acquired as established in section 5 of order CIN/308/2009, aerospace vehicles, propulsion systems aerospace, aerospace materials, airport infrastructures, air navigation infrastructures and any space, traffic and air transport management system.
CG03	Installation, operation and maintenance in the field of aeronautical engineering that have as their object, in accordance with the knowledge acquired as established in section 5 of order CIN/308/2009, aerospace vehicles, aerospace propulsion systems, materials aerospace, airport infrastructure, air navigation infrastructure and any space, traffic and air transport management system.
CG05	Ability to carry out activities of projection, technical direction, expert opinion, report writing, opinions, and technical advice on tasks related to Aeronautical Technical Engineering, exercise of functions and genuine aerospace technical positions.
CG06	Ability to participate in flight test programs to collect data on takeoff distances, climb rates, stall rates, maneuverability, and landing capabilities.
CT03	Correct use of oral and written communication.

5. Objectives or Learning Outcomes

Course learning outcomes

Description

Knowledge of the problem and calculations associated with the external and internal fluid dynamics and aerodynamics of the different equipment and systems of vehicles in the aerospace field.

Knowledge of the devices and geometries conditioned by aerodynamics in the different aircraft systems.

6. Units / Contents

Unit 1: Introduction to Aerodynamics

- **Unit 1.1** Aerodynamic forces and moments
- **Unit 1.2** Center of pressure
- **Unit 1.3** Stalling speed and aerodynamic efficiency
- **Unit 1.4** Types of flow
- **Unit 1.5** Boundary layer theory
- **Unit 1.6** Magnitudes and variations of the aerodynamic coefficients

Unit 2: Potential flow extension

- **Unit 2.1** Numerical source panel method
- **Unit 2.2** Flow over a circular cylinder, the real case

Unit 3: Incompressible flow over airfoils

- **Unit 3.1** Airfoil nomenclature and characteristic. Polar.
- **Unit 3.2** Vortex sheet. Solutions for low.speed flow over airfoils.
- **Unit 3.3** The Kutta condition
- **Unit 3.4** Kelvin circulation theorem and the starting vortex
- **Unit 3.5** Classical thin airfoil theory. Simetric and cambered airfoils.
- **Unit 3.6** Vortex panel numerical method
- **Unit 3.7** Modern low-speed airfoils
- **Unit 3.8** Airfoil drag
- **Unit 3.9** Types of stall. High-lift devices.

Unit 4: Incompressible flow over finite wings

- **Unit 4.1** Downwash and induced drag
- **Unit 4.2** Biot-Savart law and Helmholtz theorems
- **Unit 4.3** Prandtl classical lifting-line theory. Elliptical lift and general lift distributions. Effect of aspect ratio.
- **Unit 4.4** Span loading
- **Unit 4.5** Numerical nonlinear lifting-line method
- **Unit 4.6** The lifting-surface theory and the vortex lattice numerical method
- **Unit 4.7** Low-aspect-ration and swept wings
- **Unit 4.8** Delta wings

Unit 5: Three-dimensional incompressible flow

- **Unit 5.1** Three-dimensional basic potential flows
- **Unit 5.2** Flow over a sphere
- **Unit 5.3** Three-dimensional panel techniques
- **Unit 5.4** Real flow over a sphere
- **Unit 5.5** Airpane lift and drag. Wing-body interaction.

Unit 6: Compressible flow

- **Unit 6.1** Review of Themodynamics
- **Unit 6.2** Stagnation conditions
- **Unit 6.3** normal hosck waves
- **Unit 6.4** Oblique shock waves
- **Unit 6.5** Shock-wave/boudary-layer interaction
- **Unit 6.6** Bow shock
- **Unit 6.7** Prandtl-Meyer expansion waves

Unit 7: Subsonic compressible flow

- **Unit 7.1** The velocity potential equation and its linearized version
- **Unit 7.2** Prandtl-Glauert and improved compressibility corrections
- **Unit 7.3** Transonic regime. Critical and drag-divergence Mach numbers. The area rule. Supercritical airfoils.

Unit 8: Supersonic flow

- **Unit 8.1** Aplication to supersonic airfoils of the shock-expansion theory
- **Unit 8.2** Linearized supersonic pressure coefficient formula
- **Unit 8.3** Supersonic area rule
- **Unit 8.4** Supersonic airfoul drag
- **Unit 8.5** Slender-body theory. Flow over cones.

Unit 9: Laboratory

- **Unit 9.1** Measure of velocity in compressible flow
- **Unit 9.2** Subsonic and supersonic inlets. Other devices affect by aerodynamics.
- **Unit 9.3** Supersonic wind tunnels
- **Unit 9.4** Computational Fluid Dynamics

7. Activities, Units/Modules and Methodology

Training Activity	Methodology	Related Competences (only degrees before RD 822/2021)	ECTS	Hours	As	Com	Description
Class Attendance (theory) [ON-SITE]	Lectures	CA01 CA02 CA03 CA04 CA05 CA06 CB02 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CE26 CG01 CG03 CG05 CG06 CT03	1.6	40	N	-	Development in the classroom of the theoretical contents.
Problem solving and/or case studies [ON-SITE]	Project/Problem Based Learning (PBL)	CA01 CA02 CA03 CA04 CA05 CA06 CB02 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CE26 CG01 CG03 CG05 CG06 CT03	0.4	10	Y	N	Resolution of exercises and problems in the classroom in a collective way.
Laboratory practice or sessions [ON-SITE]	Practical or hands-on activities	CA01 CA02 CA03 CA04 CA05 CA06 CB02 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CE26 CG01 CG03 CG05 CG06 CT03	0.24	6	Y	N	Laboratory experiments where the student developes the knowledge acquired in the theoretical classes through experimentation.
Writing of reports or projects [OFF-SITE]	Cooperative / Collaborative Learning	CA01 CA02 CA03 CA04 CA05 CA06 CB02 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CE26 CG01 CG03 CG05 CG06 CT03	0.6	15	Y	Y	Continuining the work begun in laboratory, students must cooperatively prepare a report where they analyze and show the results and conclusions of their experiments. The student who obtains less than 40% of the maximum mark will be able to recover this part in the final exam.
Progress test [ON-SITE]	Assessment tests	CA01 CA02 CA03 CA04 CA05 CA06 CB02 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CE26 CG01 CG03 CG05 CG06 CT03	0.06	1.5	Y	N	Mid-term written test (first one) to eliminate the subject, which contains problems and/or theoretical questions corresponding approximately to the first half of the course. The student who obtains less than 40% of the maximum mark will be able to pass this part in the final exam.
Final test [ON-SITE]	Assessment tests	CA01 CA02 CA03 CA04 CA05 CA06 CB02 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CE26 CG01 CG03 CG05 CG06 CT03	0.1	2.5	Y	Y	Final test with problems and/or theoretical questions referring to the whole course.
Study and Exam Preparation [OFF-SITE]	Self-study	CA01 CA02 CA03 CA04 CA05 CA06 CB02 CB03 CB04 CB05 CE02 CE08 CE10 CE15 CE16 CE18 CE19 CE21 CE25 CE26 CG01 CG03 CG05 CG06 CT03	3	75	N	-	Self-study of theory and problems, from which the student parctices and fixes the knowledge learned in classes in the classroom.
		Total:	**6**	**150**			
Total credits of in-class work: 2.4							**Total class time hours: 60**
Total credits of out of class work: 3.6							**Total hours of out of class work: 90**

As: Assessable training activity

Com: Training activity of compulsory overcoming (It will be essential to overcome both continuous and non-continuous assessment).

8. Evaluation criteria and Grading System

Evaluation System	Continuous assessment	Non-continuous evaluation*	Description
Mid-term tests	45.00%	0.00%	C: mid-term tests with contents of the course NC: it does not apply
Practicum and practical activities reports assessment	10.00%	10.00%	C: realization of laboratory experiments and delivery of a report NC: this part will be evaluated in the final test through questions related to the laboratory experiences.
Final test	45.00%	90.00%	C: it does not apply NC: final test (with the contents of all the partial tests)
Total:	**100.00%**	**100.00%**	

According to art. 4 of the UCLM Student Evaluation Regulations, it must be provided to students who cannot regularly attend face-to-face training activities the passing of the subject, having the right (art. 12.2) to be globally graded, in 2 annual calls per subject , an ordinary and an extraordinary one (evaluating 100% of the competences).

Evaluation criteria for the final exam:

Continuous assessment:

Who obtains equal to or more than 40% of the maximum mark in the first mid-term test and 40% of the maximum mark in the laboratory part, may decide to only take the second mid-term test (which corresponds to the second half of the subject) in the final exam. Otherwise, he must repeat the first mid-term test and/or the laboratory part during the final test. To pass the subject, it is necessary to obtain at least 40% of the mark in each mid-term test and in the laboratory, and to get an average mark equal to or greater than 50% of the maximum mark of the course.

Non-continuous evaluation:

Who does not access the continuous evaluation will be evaluated in the final test, which will include questions related to the laboratory experiences.

Specifications for the resit/retake exam:

Same evaluation criteria will be applied as in the non-continuous evaluation.

Specifications for the second resit / retake exam:

Same evaluation criteria will be applied as in the non-continuous evaluation.

9. Assignments, course calendar and important dates

Not related to the syllabus/contents

Hours	hours
Writing of reports or projects [AUTÓNOMA][Cooperative / Collaborative Learning]	15
Progress test [PRESENCIAL][Assessment tests]	1.5
Final test [PRESENCIAL][Assessment tests]	2.5
Study and Exam Preparation [AUTÓNOMA][Self-study]	75

General comments about the planning: This time distribution could be modified behind particular circumstances, happening during the development of the course, so advise. The contents, methodology and evaluation systems of the subject could be modified, with the authorization of the university authorities. In any case, the acquisition of the skills of the subject will be ensured.

Unit 1 (de 9): Introduction to Aerodynamics

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2

Unit 2 (de 9): Potential flow extension

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2

Unit 3 (de 9): Incompressible flow over airfoils

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	8
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	3

Unit 4 (de 9): Incompressible flow over finite wings

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	8
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	3

Unit 5 (de 9): Three-dimensional incompressible flow

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	4

Unit 6 (de 9): Compressible flow

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	4

Unit 7 (de 9): Subsonic compressible flow

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	6
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	2

Unit 8 (de 9): Supersonic flow

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	4
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	2

Unit 9 (de 9): Laboratory

Activities	Hours
Class Attendance (theory) [PRESENCIAL][Lectures]	2
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	6

Global activity

Activities	hours
Class Attendance (theory) [PRESENCIAL][Lectures]	40
Writing of reports or projects [AUTÓNOMA][Cooperative / Collaborative Learning]	15
Progress test [PRESENCIAL][Assessment tests]	1.5
Final test [PRESENCIAL][Assessment tests]	2.5
Problem solving and/or case studies [PRESENCIAL][Project/Problem Based Learning (PBL)]	10
Study and Exam Preparation [AUTÓNOMA][Self-study]	75
Laboratory practice or sessions [PRESENCIAL][Practical or hands-on activities]	6
Total horas:	150

10. Bibliography and Sources

Author(s)	Title/Link	Publishing house	Citv	ISBN	Year	Description
J.J. Bertin & R.M. Cummings,	Aerodynamics for engineers	Pearson Prentice-Hall		978-0-13-235521-6	2009	
J.D. Anderson Jr.	Fundamentals of Aerodynamics	McGraw-Hill Education		978-12-5912-991-9	2016	
J.M. Gordillo & G. Riboux	Introducción a la Aerodinámica potencial	Paraninfo		978-84-9732-994-1	2012	
J. Meseguer & A. Sanz	Aerodinámica básica	Garceta		978-84-9281-271-4	2011	
A. Barrero, J. Meseguer, A. Sanz	Aerodinámica de altas velocidades	Garceta		978-84-9281-294-3	2011	
F. Gandía, J. Gonzalo, X. Margot, J. Meseguer	Fundamentos de los métodos numéricos en Aerodinámica	Garceta		978-84-1545-247-8	2013	