



## (\*)Escola de Enxeñaría Aeronáutica e do Espazo

### Presentation

The School of Aeronautic and Space Engineering (EEAE) of the University of Vigo at the Campus of Ourense offers the degrees of the University of Vigo that are related both to bachelor's and to master's level in the field of aeronautical or aerospace engineering.

More information about the Center and its degrees is found in this document or on the web page (<http://aero.uvigo.es>).

### Address

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### Regulations and legislation

The information is available on the Center's web site (<http://aero.uvigo.es> in the section: School -> Regulations).

## (\*)Máster Universitario en Enxeñaría Aeronáutica

### Subjects

#### Year 1st

Code	Name	Quadmester	Total Cr.
007M197V01101	Advanced aerodynamics and aeroelasticity	1st	6
007M197V01102	Advanced aerospace materials and production	1st	9
007M197V01103	Design, calculation and certification of aircraft and space vehicles	1st	9
007M197V01104	Advanced fluid mechanics	1st	6
007M197V01201	Advanced fluid mechanics	2nd	6
007M197V01202	Advanced calculation of aerospace structures	2nd	6
007M197V01203	Design, calculation and certification of aerospace propulsion systems	2nd	6

O07M197V01204	Advanced air navigation systems	2nd	6
O07M197V01205	Avionics	2nd	6

**IDENTIFYING DATA****Advanced aerodynamics and aeroelasticity**

Subject	Advanced aerodynamics and aeroelasticity			
Code	O07M197V01101			
Study programme	(*)Máster Universitario en Enxeñería Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	1st
Teaching language	Spanish			
Department				
Coordinator	Navarro Medina, Fermín			
Lecturers	Navarro Medina, Fermín			
E-mail	fermin.navarro.medina@uvigo.es			
Web	http://aero.uvigo.es			
General description	The subject of "advanced aerodynamics and aeroelasticidad" deepens in in the methods of calculation of the aerodynamic and aeroelastic loads that a fluid exerts on aerodynamic, slender and blunt bodies in distinct ranges of flight ranges of aircraft. It deepens also in the aerodynamic phenomena in subsonic, transonic, supersonic and hypersonic flight of aircraft or other vehicles, and in static and dynamic aeroelastic phenomena.			

**Training and Learning Results**

Code	
A3	Understanding and mastering the laws of external aerodynamics in different flight regimes, and application to numerical and experimental aerodynamics
A4	Application of knowledge acquired in different disciplines to solve complex aeroelasticity problems
A9	Ability to design, execute and analyze ground and flight tests of aerospace vehicles, and to carry out a complete aerospace vehicle certification process.
A14	Understanding and mastery of the laws of internal aerodynamics, as well as their application, together with other disciplines, to the resolution of complex aeroelasticity and propulsive systems problems.

**Expected results from this subject**

Expected results from this subject	Training and Learning Results
Knowledge and understanding of the potential theory of subsonic and supersonic wings.	A3 A14
Capacity to resolve aerodynamic problems applying the knowledges learnt.	A3 A14
Knowledge, understanding, application, analysis and synthesis of the methods applied to the study of the respond of aircraft unsteady loads.	A3 A4 A9
Knowledge, understanding, application, analysis and synthesis of the methods applied to the aeroelastic study.	A4
Knowledge, understanding, application, analysis and synthesis of aeroelasticity for wings, from a static and dynamic point of view.	A4 A9
Knowledge and understanding of the most important phenomena of the experimental aeroelasticity.	A4 A9

**Contents**

Topic	
1. Subsonic aerodynamics	<ul style="list-style-type: none"> <li>o Potential theory of wings in a subsonic compressible regime.</li> <li>o Subsonic and supersonic air intakes.</li> <li>o Numerical techniques of whirlwind methods.</li> <li>o Experimental techniques (wind tunnels, instrumentation and test techniques).</li> </ul>
2. Supersonic aerodynamics	<ul style="list-style-type: none"> <li>o Transonic phenomena in profiles and wings.</li> <li>o Supersonic wing power theory.</li> <li>o Potential theory of slender bodies.</li> <li>o Subsonic and supersonic air intakes.</li> <li>o Hypersonic regime</li> </ul>

3. Static aeroelasticity	<ul style="list-style-type: none"> <li>o Continuous systems and discrete systems. Forced vibrations of continuous systems.</li> <li>o Approximate methods for solving continuous systems. Static aeroelasticity of the wings. Divergence and reversal of command.</li> </ul>
4. Dynamic aeroelasticity	<ul style="list-style-type: none"> <li>o Dynamic aeroelasticity of wings.</li> <li>o Advanced aeroelasticity. Aeroelasticity in the Laplace domain. Nonlinear aeroelasticity. Aeroservoelasticity.</li> <li>o Structural dynamics and aeroelasticity tests. Aeroelastic tests in flight.</li> </ul>

### Planning

	Class hours	Hours outside the classroom	Total hours
Case studies	10	60	70
Laboratory practical	2	2	4
Lecturing	29	0	29
Problem solving	4.5	0	4.5
Autonomous problem solving	0	10	10
Previous studies	0	30	30
Objective questions exam	1.5	0	1.5
Presentation	1	0	1

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

### Methodologies

	Description
Case studies	Realization of practical case studies on the contents of the subject, which will be explained and started in the classroom to be finished and delivered by the students outside the classroom. The case studies will require the use of software and/or the wind tunnel.
Laboratory practical	Realization of programmed practices using the wind tunnel. The realization of the practical requires the preparation of the same by means of a previous design, the assistance to the practical sessions and the realization of a report on the part of the group of students.
Lecturing	Presentation of a topic or resolution of problems by the teaching staff according to a previously established script.
Problem solving	Resolution of problems and/or exercises that deal with specific aspects of the contents of the subject, developed by the teaching staff and/or the students in the classroom
Autonomous problem solving	Resolution of problems and/or exercises that deal with specific aspects of the contents of the subject, developed by the students outside the classroom
Previous studies	Students study autonomously, with the support of the teaching staff if required according to the procedures established by the university for tutorials

### Personalized assistance

Methodologies	Description
Case studies	Realization of practical case studies on the contents of the subject, which will be explained and started in the classroom to be finished and delivered by the students outside the classroom. The students will have the necessary tutorials with the teaching staff to monitor the development of the case studies.
Previous studies	Support tutorials for students to study independently, according to the procedures established by the university.

### Assessment

	Description	Qualification	Training and Learning Results
Case studies	Five study cases for the resolution of which software and/or experimentation will be used. The qualification of each of them will be 10% (three of the study cases), and 15% (two of the study cases).	60	A3 A4 A9 A14
Objective questions exam	Exam based on the resolution of problems and/or conceptual questions about the contents of the subject. It will be on the official exam date. Minimum note of 5.0.	35	A3 A4 A9 A14
Presentation	Presentations of the results of the case studies to be carried out by the students throughout the course.	5	A3 A4 A14

### Other comments on the Evaluation

## First call

To pass the subject on the 1st opportunity, it will be necessary to obtain a score of more than 5 points out of 10 in the joint evaluation of the continuous evaluation during the development of the classes and the exam on the official date. In addition, the exam grade on the official date must be greater than or equal to 5 points out of 10. The final grade of the continuous assessment will be obtained according to the indicated percentages.

For the global evaluation, an exam will be carried out on the day of the official date, which includes all the contents of the subject, including the contents and methods used in the case studies. The qualification of said exam to pass the subject will be 5 points out of 10.

The evaluation test schedule officially approved by the Junta de Centro da EEAE is published on the web

<http://aero.uvigo.es/gl/docencia/exames>

Continuous assessment tests will be carried out during school hours"

The student has the right to opt for the global assessment according to the procedure and the deadline established by the centre for each call.

## Second call

The student must take the second call exam of all the contents of the subject, which will mean 100% of the grade, if the final continuous assessment grade is less than 5 points out of 10. They will also have to sit the second call exam in the following cases:

- Obtain a grade of less than 5 points out of 10 in the first chance final exam

In case of obtaining a grade greater than or equal to 5 in the second chance exam, the final grade for the subject will be the highest grade between:

\* the 2nd call exam

\* the average with the activities carried out during the course (averaging with the percentages of the evaluation table substituting the mark of the first call exam for the second call)

## End-of-program call

For the end of degree evaluation, an exam will be held on the day of the official date, which includes all the contents of the subject. The qualification of said exam to pass the subject will be 5 points out of 10.

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### Sources of information

#### Basic Bibliography

A. Barrero Ripoll, **Aerodinámica de altas velocidades**, 978-84-9281-246-21, Garceta Grupo Editorial, 2011

#### Complementary Bibliography

Wright, J.R. and Cooper, J.E., **Introduction to Aircraft Aeroelasticity and Loads**, 978-0470-85840-0, John Wiley & Sons Ltd. 2007, 2007

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### Recommendations

#### Subjects that continue the syllabus

Advanced fluid mechanics/O07M197V01201

#### Subjects that are recommended to be taken simultaneously

Advanced fluid mechanics/O07M197V01104

**IDENTIFYING DATA****Materiais e produción aeroespacial avanzados**

Subject	Materiais e produción aeroespacial avanzados			
Code	O07M197V01102			
Study programme	Máster Universitario en Enxeñería Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	9	Mandatory	1	1c
Teaching language	Castelán			
Department				
Coordinator	Carou Porto, Diego			
Lecturers	Álvarez González, David Carou Porto, Diego			
E-mail	diecapor@uvigo.es			
Web	<a href="http://aero.uvigo.es">http://aero.uvigo.es</a>			
General description	Asignatura de materiais avanzados para a industria aeroespacial e produción.			

**Resultados de Formación e Aprendizaxe**

Code				
A6	Coñecemento adecuado dos materiais metálicos e materiais compostos utilizados na fabricación de vehículos aeroespaciais			
A7	Coñecementos e habilidades que permitan comprender e levar a cabo os procesos de fabricación de vehículos aeroespaciais			
A15	Coñecemento adecuado dos materiais e procesos de fabricación empregados nos sistemas de propulsión			

**Resultados previstos na materia**

Expected results from this subject	Training and Learning Results
Coñecemento axeitado dos materiais metálicos e materiais compostos empregados na fabricación de vehículos aeroespaciais	A6 A7
Coñecemento e capacidades que permiten comprender e realizar os procesos de fabricación dos vehículos aeroespaciais.	A15
Coñecemento axeitado dos materiais e procesos de fabricación empregados nos sistemas de propulsión	

**Contidos**

Topic	
Bloque Materiais	<ol style="list-style-type: none"> <li>1. Criterios de selección e comportamento en servizo dos materiais aeroespaciais. <ul style="list-style-type: none"> <li>-Introdución á selección de materiais.</li> <li>-Parámetros de deseño.</li> <li>-Propiedades mecánicas , térmicas, eléctricas, resistencia ao medio.</li> </ul> </li> <li>2. Materiais metálicos avanzados para estruturas aeronáuticas. <ul style="list-style-type: none"> <li>-Aliaxes de aluminio avanzadas.</li> <li>-Aceiros inoxidables avanzados.</li> <li>-Materiais compostos matriz polimérica.</li> </ul> </li> <li>3. Materiais metálicos avanzados para sistemas propulsivos aeronáuticos e espaciais. <ul style="list-style-type: none"> <li>-Aliaxes de Titanio</li> <li>-Superalcaciones</li> <li>-Cerámicos</li> <li>-Materiais compostos de matriz cerámica</li> </ul> </li> <li>4. Análise de Fallos en Servizo <ul style="list-style-type: none"> <li>-Resistencia a corrosión</li> <li>-Termofluencia</li> <li>-Fractografía</li> <li>-Fatiga</li> </ul> </li> </ol>

## Bloque Producción

1. Introducción
2. Procesos de mecanizado non convencional
3. Micromecanizado
4. Fabricación aditiva de materiais compostos
5. Procesos de acabado e tratamento superficial
6. Introducción a sistemas de produción
7. Economía da fabricación
8. Equilibrado de liñas
9. Tecnoloxía de grupos

### Planificación

	Class hours	Hours outside the classroom	Total hours
Lección maxistral	30	30	60
Resolución de problemas	12	20	32
Prácticas de laboratorio	10	20	30
Prácticas con apoio das TIC	16	30	46
Traballo tutelado	0	53	53
Exame de preguntas obxectivas	4	0	4

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

### Metodoloxía docente

	Description
Lección maxistral	Exposición por parte do profesor dos contidos fundamentais da materia.
Resolución de problemas	Presentación e resolución por parte do profesor de problemas relativos aos procesos de fabricación estudados de maneira teórica coa participación activa das/os estudantes.
Prácticas de laboratorio	Introdución ao traballo con equipos de fabricación no laboratorio.
Prácticas con apoio das TIC	Introdución ao emprego de software de simulación de procesos de fabricación por parte do profesor. Coas instrucións recibidas e traballo autónomo, as/os estudantes poderán resolver problemas específicos que permitan mellorar o seu coñecemento sobre os procesos estudados.
Traballo tutelado	Realización de traballo individual e en grupos sobre temáticas propostas e realización de presentacións orais.

### Atención personalizada

Methodologies	Description
Lección maxistral	
Prácticas de laboratorio	
Prácticas con apoio das TIC	
Traballo tutelado	
Resolución de problemas	

### Avaliación

	Description	Qualification	Training and Learning Results
Resolución de problemas	Entrega de problemas propostos resoltos	10	A6 A7 A15
Prácticas de laboratorio	Entrega de informes	15	A6 A7 A15
Prácticas con apoio das TIC	Entrega de informes	15	A6 A7 A15
Traballo tutelado	Entrega de memorias e realización de presentacións	30	A6 A7 A15
Exame de preguntas obxectivas	Cuestionario	30	A6 A7 A15

### Other comments on the Evaluation

O modelo de avaliación é avaliación continua. O/A estudante ten dereito a optar pola avaliación global segundo o

procedemento e o prazo que estableza o centro para cada convocatoria. O exame global consistirá nun exame escrito en data oficial que cubra todos os aspectos avaliados en avaliación continua.

### **PRIMEIRA OPORTUNIDADE:**

A materia avalíase en base a catro parámetros:

-Exames teórico-prácticos (nota máxima 2 puntos). Consistirán en dúas probas para cada unha das partes (materiais e produción). A primeira durante o desenvolvemento do curso e a segunda na data oficial de exame.

Nestas probas avalíanse os coñecementos teóricos da materia, cuestións relacionadas cos problemas e prácticas mediante un exame tipo test e resposta curta. O primeiro exame valórase en 1 punto e o segundo en 1 punto.

-Resolución de problemas (nota máxima 2 puntos). Avaliarase a entrega da resolución aos problemas expostos durante o curso nos prazos establecidos.

-Prácticas de laboratorio (nota máxima 1 punto). Deberase participar nas actividades propostas durante o curso e entregar os informes requiridos.

-Prácticas con apoio do TIC (nota máxima 1 punto). Deberase participar nas actividades propostas durante o curso e entregar os informes requiridos.

-Traballo tutelado (nota máxima 4 puntos). Deberase realizar o traballo solicitado e entregar unha memoria completa.

Aprobarán a materia aqueles alumnos que consigan unha nota igual ou superior a 5 puntos. Non se fará media no caso de que nunha parte a nota sexa inferior a 3,5 puntos, sendo a nota final de actas a nota da parte que non alcance o valor mínimo.

Non é posible recuperar ningunha proba a posteriori, salvo causa xustificada.

### **SEGUNDA OPORTUNIDADE:**

O método de Avaliación é o mesmo que o descrito para a PRIMEIRA OPORTUNIDADE.

Poderanse gardar traballos da primeira oportunidade con cualificación >5. En ningún caso gardarase a cualificación dos exames.

### **OUTRAS CONSIDERACIÓNS:**

En caso de detección de plaxio en calquera das probas, a cualificación final será de SUSPENSO (0) e o feito será comunicado á dirección do Centro para os efectos oportunos.

As probas desenvolveranse durante o cuadrimestre. O exame teórico-práctico inicial desenvolverase en data a definir e indicada ás/os estudantes con antelación suficiente.

O calendario de probas de avaliación aprobado oficialmente pola Xunta de Centro da EEAE atópase publicado na páxina web <http://aero.uvigo.es/gl/docencia/exames>

A avaliación fin de carreira seguirá os mesmos criterios ca avaliación de 2ª oportunidade.

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### **Bibliografía. Fontes de información**

#### **Basic Bibliography**

Mikell P. Groover, **Automation, production systems, and computer-integrated manufacturing**, 978-1-292-07611-9, Pearson, 2016

Lee Harper, Mike Clifford (EDITORS), **Design and Manufacture of Structural Composites**, 9780128191606, Elsevier, 2022

Abdel Salam Hamdy Makhlouf y Mahmood Aliokhazraei (edited), **Handbook of materials failure analysis with case studies from the aerospace and automotive industries**, 9780128009505, Elsevier, 2016

#### **Complementary Bibliography**

Michael F. Ashby, **Materiales para la ingeniería. Introducción a la microestructura, el procesamiento y el diseño, volumen 2**, Reverté, 2009

N.E. Prasad, **Aerospace materials and materials technologies**, Springer, 2017

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### **Recomendacións**



**IDENTIFYING DATA****Design, calculation and certification of aircraft and space vehicles**

Subject	Design, calculation and certification of aircraft and space vehicles			
Code	O07M197V01103			
Study programme	(*)Máster Universitario en Enxeñaría Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	9	Mandatory	1st	1st
Teaching language	Spanish			
Department				
Coordinator	Gómez San Juan, Alejandro Manuel			
Lecturers	Gómez San Juan, Alejandro Manuel			
E-mail	alejandromanuel.gomez@uvigo.es			
Web				
General description	(*)A materia "Deseño, cálculo e certificación de aeronaves e vehículos espaciais" é unha disciplina de enxeñaría aplicada. Nela faise uso dos coñecementos apresos no grao para abordar, a fase inicial de deseño conceptual segundo requisitos de deseño, e as dúas fases de *validación do deseño, o cálculo e a *validación/certificación. No primeiro bloque da materia séguese este proceso para aeronaves e no segundo para vehículos espaciais			

**Training and Learning Results**

Code	
A1	Ability to design, build, inspect, certify and maintain all types of aircraft and spacecraft
A5	Understanding and mastery of atmospheric flight mechanics (performance, stability, static and dynamic control), orbital mechanics and attitude dynamics.
A8	Knowledge and skills for the structural analysis and design of aircraft and spacecraft, including the application of advanced structural design and calculation programs
A9	Ability to design, execute and analyze ground and flight tests of aerospace vehicles, and to carry out a complete aerospace vehicle certification process.
A10	Adequate knowledge of the different subsystems of aircraft and spacecraft

**Expected results from this subject**

Expected results from this subject	Training and Learning Results
GO1. Aptitude to project, build, inspect, certify and keep all type of aircraft and space vehicles	A1
GO5. Understanding and command of the mechanics of atmospheric flight (performances, stability, static and dynamic control), of the orbital mechanics and of the dynamics of attitude.	A5
GO8. Knowledges and capacities for the analysis and structural design of the aircraft and space vehicles, including the application of programs of calculation and design advanced of structures	A8
GO9. Capacity to design, execute and analyse the essays in earth and in flight of the aerospace vehicles, and to carry out a complete process of certification of the same.	A9
GO10. Suitable knowledge of the distinct subsystems of the aircraft and space vehicles.	A10

**Contents**

Topic	
Aircraft: requirements and preliminary design	-General configuration of aircraft of transport. -Characteristic mass, aerodynamic and *propulsivas. -Calculation of performances -Extension to other aircraft
Aircraft: conceptual design and architecture	-Structure -Systems and teams of tackle.
Aircraft: certification and essays	-Certification of the aeronavegability -Essays of certification -Investigation of accidents.

Space vehicles: requirements and preliminary design	-Space missions -Surroundings of operation and development -Orbit -Geometry of space missions
Space vehicles: conceptual design and architecture	-Subsystems of space vehicles -Power -Structure -thermal Control -AOCS -Communications
Space vehicles: verification and essays	-Guarantee of product -Integration and essays

### Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	41	41	82
Problem solving	6	18	24
Practices through ICT	20	20	40
Mentored work	1	74	75
Essay questions exam	2	0	2
Case studies	2	0	2

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

### Methodologies

	Description
Lecturing	Exhibition of a subject or resolution of problems by part of the professor according to a previously established script.
Problem solving	Resolution of problems and/or exercises that treat punctual appearances of the contents of the subject, developed by the professor and/or the students in the classroom
Practices through ICT	Use of the available means TIC in the school to tackle the predesign so much of aircraft as of space vehicles
Mentored work	Realisation of cases of practical study with delivery of work on the contents of the subject, the which will be explained and initiated in the classroom to be finished and delivered by part of the students out of the classroom. The students will have of the tutorials necessary with the professor for the follow-up of the development of the cases of study.

### Personalized assistance

Methodologies	Description
Mentored work	Realisation of cases of practical study on the contents of the subject, the which will be explained and initiated in the classroom to be finished and delivered by part of the students out of the classroom. The students will have of the tutorships necessary with the professor for the follow-up of the development of the cases of study.

### Assessment

	Description	Qualification	Training and Learning Results
Essay questions exam	Examination based in the resolution of problems and/or conceptual questions on the contents of the subject. It will be in date of official examination. Minimum note of 5.0.	40	A1 A5 A8 A9 A10
Case studies	In the subject will develop two cases of study, one for aircraft and another for space vehicles. In each one of them will have to make the preliminary and conceptual design of a vehicle, using the materials given in class and the half available TIC. The works will present in class and each one of them will suppose 30% of the note of the subject.	60	A1 A5 A8 A9 A10

### Other comments on the Evaluation

First Chance Assessment

Continuous assessment

To pass the subject on the 1st opportunity, it will be necessary to obtain a score of more than 5 points out of 10 in the joint evaluation of the continuous evaluation during the development of the classes and the exam on the official date. In addition, the exam grade on the official date must be greater than or equal to 5 points out of 10. The final grade of the continuous assessment will be obtained according to the indicated percentages. The default evaluation mode will be continuous evaluation.

#### Overall evaluation

For the global evaluation, an exam will be carried out on the day of the official date, which includes all the contents of the subject, including the contents and methods used in the case studies. The qualification of said exam to pass the subject will be 5 points out of 10.

The evaluation test schedule officially approved by the Junta de Centro da EEAE is published on the web

<http://aero.uvigo.es/gl/docencia/exames>

Continuous assessment tests will be carried out during school hours.

The student has the right to opt for the global evaluation according to the procedure and the term established by the center for each call.

#### second chance assessment

The student body must take the second call exam of all the contents of the subject, which will mean 100% of the grade, if the final continuous assessment grade is less than 5 points out of 10. They will also have to sit the second call exam in the following cases:

- Obtain a grade of less than 5 points out of 10 in the first chance final exam

In case of obtaining a grade greater than or equal to 5 in the second chance exam, the final grade for the subject will be the highest grade between:

\* the 2nd call exam

\* the average with the activities carried out during the course (averaging with the percentages of the evaluation table substituting the mark of the first call exam for the second call)

#### End of career evaluation

For the end of degree evaluation, an exam will be held on the day of the official date, which includes all the contents of the subject. The qualification of said exam to pass the subject will be 5 points out of 10.

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### Sources of information

#### Basic Bibliography

#### Complementary Bibliography

J. Anderson, **Aircraft Performance & Design**, 978-0070019713, 1, McGraw-Hill Education, 1988

D. P. Reymer, **Aircraft Design: A Conceptual Approach**, 978-1624104909, 6, American Institute of Aeronautics & Ast., 2018

P. Fortescue, **Spacecraft Systems Engineering**, 978-0471619512, 3, Wiley, 2003

W. Larson, J. Wertz, **Space Mission Analysis and Design**, 978-0792359012, 3, Springer, 1999

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### Recommendations

#### Subjects that continue the syllabus

Advanced calculation of aerospace structures/O07M197V01202

Design, calculation and certification of aerospace propulsion systems/O07M197V01203

Space mechanical, thermal and electrical systems/O07M197V01303

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**IDENTIFYING DATA****Advanced fluid mechanics**

Subject	Advanced fluid mechanics			
Code	O07M197V01104			
Study programme	(*)Máster Universitario en Enxeñería Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	1st
Teaching language	Spanish			
Department				
Coordinator	Martín Ortega, Elena Beatriz			
Lecturers	Martín Ortega, Elena Beatriz			
E-mail	emortega@uvigo.es			
Web				
General description	Subject that includes advanced knowledge of fluid flows, from a theoretical and numerical perspective, including also reactive flows.			

**Training and Learning Results**

Code	
A2	Adequate knowledge of advanced fluid mechanics, with special emphasis on computational fluid mechanics and turbulence phenomena
A12	Adequate knowledge of advanced fluid mechanics, with special emphasis on experimental and numerical techniques used in fluid mechanics.
A13	Understanding and mastering the phenomena associated with combustion and heat and mass transfer.

**Expected results from this subject**

Expected results from this subject	Training and Learning Results
Know how to analyse flows (both incompressible and compressible flows, including flows with combustion) by means Computational Dynamics Techniques	A2 A12 A13
In this subject, we will focus on:	
- using numerical and/or analytical methods to solve a fluid flow problem	
- Working by projects	

**Contents**

Topic	
1. REVISION OF NAVIER-STOKES EQUATIONS	1.1. Principles of conservation of mass, linear momentum and energy. 1.2. Euler Equations. 1.3. Initial and boundary conditions 1.4. Dimensionless formulation, dimensionless parameters and physical similarity. Application to Rayleigh problem.
2. BOUNDARY LAYERS	2.1 Introduction. Equations of the boundary layer. Introduction to perturbations. Thicknesses and general considerations. Laminar boundary layers 2.2. Integral equation of Karman. 2.3. Blasius Solution. Effects of suction/blown. 2.4. Solutions of Falkner-Skan. 2.5. Thermal boundary layer 2.6. Effects of compressibility. Boundary layers at very high speed

2. NAVIER-STOKES EQUATIONS FOR REACTIVE MIXTURES	<p>2.1 Multicomponents mixtures: molar Fraction. Mass fraction. Equation of state. Speed of diffusion.</p> <p>2.2 Conservation Equation for the chemical species. Molecular transport in multicomponents mixtures. Navier-Stokes Equations for reactive flows</p> <p>2.3 Introduction to the chemistry of combustion. Global and elementary reactions. Dependency of the constants of reaction with the temperature. Hypothesis of steady state. Hypothesis partial equilibrium</p> <p>2.4 Thermokinetics. Steichometry and dosage. Adibatic flame temperature. Chemical balance.</p> <p>2.5 Length and time scales. Relevant dimensionless numbers</p> <p>2.6 Applications. Numerical simulation of combustion processes</p>
3. TURBULENCE	<p>3.1 I Review of properties of turbulence. Free turbulence. Turbulent dynamic boundary layer. Turbulent thermal boundary layer</p> <p>3.2 RANS and LES models.</p>
4. ADVANCED NUMERICAL TECHNIQUES IN FLUID DYNAMICS	<p>4.1 Finite Volume Methods (FVM)</p> <p>4.2 Implementation of the FVM</p> <p>4.3 Pressure based methods. Density based methods</p> <p>4.4 Examples of discretisation</p> <p>4.5 Residuals and their meaning.</p> <p>4.6 Numerical Simulation of different compressible and incompressible flows</p>
5. INTRODUCTION TO EXPERIMENTAL MEASUREMENTS IN FLUIDS	<p>5.1. Characterisation of Turbulent Flow</p> <p>5.2. Measurement of Temperature and Heat flow</p> <p>5.3 Measure of Pressure</p> <p>5.4 Measure of forces</p> <p>5.5 Hot-wire anemometer.</p> <p>5.6 Laser anemometer</p> <p>5.7 Other measurement and visualisation techniques for fluids</p>

<b>Planning</b>			
	Class hours	Hours outside the classroom	Total hours
Lecturing	29	0	29
Practices through ICT	16.5	0	16.5
Mentored work	0	62	62
Problem solving	0	40	40
Problem and/or exercise solving	2.5	0	2.5

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

<b>Methodologies</b>	
	Description
Lecturing	Explanation by the professor of the contents on the subject of study, the theoretical bases and/or the guidelines for work, exercise or project to be developed by the student.
Practices through ICT	Activities of application of knowledge to specific situations, and of acquisition of basic skills related with the subject of study in the informatic partial classes of simulation of flows
Mentored work	Activity in which one or several longer problems are formulated, where the student has to apply the knowledge acquired in the masterclasses and in the numerical simulation classes.
Problem solving	Activity in which problems and/or short exercises related with the subject are formulated. The student has to find the correct solutions by means of the application of procedures, use of available information. The student has to interpretate the obtained results. It is a complementary activity to the lectures

<b>Personalized assistance</b>	
Methodologies	Description
Lecturing	Student questions formulated during the lectures will be addressed, as well as questions asked during the computer practices. Likewise, students will be attended personally during the subject tutorships.

Practices through ICT	Student questions formulated during the lectures will be addressed, as well as questions asked during the computer practices. Likewise, students will be attended personally during the subject tutorships.
Mentored work	Students will be attended personally during the subject tutorships.
Problem solving	Students will be attended personally during the subject tutorships.

### Assessment

Description	Qualification	Training and Learning Results
Mentored work	40	A2 A12 A13
Problem solving	60	A2 A12 A13

### Other comments on the Evaluation

#### First opportunity evaluation:

To pass the subject in the 1st opportunity, the mark should be equal or greater than 5 points over 10 when averaging the marks of all the exams, works and the final mark of the exam carried out during the official exam date.

The student has right to opt for a global examination in a unique exam. To opt for this, the student should follow the official procedure established by the school.

#### Global Evaluation:

It will consist on a unique exam during the official date, that includes all the contents of the subject, including the contents and methods used in the cases of study. The marks obtained in this exam should be equal or greater than 5 points over 10 in order to pass the subject

The exams calendar will be publish in the oficial web page of the school

#### Second opportunity evaluation:

The students will take an exam taht include contents of all the subject, if the final note of the exams and works done durig the teaching period is lower that 5 points over 10.

#### End of studies exam:

For the evaluation of end of studies exam, an exam during the oficial date set by the school will be taken by the students enrolled in this type of exams. The exam will include all contents. To pass the subject, the student must obtain a mark equal or greater than 5 over 10.

### Sources of information

#### Basic Bibliography

White, F.M, **Viscous fluid flow**, 3rd ed., McGraw-Hill,, 2006

Panton, R. L., **Incompressible Flow**, 4th Edition, Wiley, 2013

Anderson, **Modern Compressible Flow**, 3rd Ed., Mc Graw Hill, 1992

H K Versteeg and W Malalasekera, **An Introduction to Computational Fluid Dynamics THE FINITE VOLUME METHOD**, 2nd Ed., Prentice Hall, 2007

### **Complementary Bibliography**

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SCHLICHTING, H., **Boundary Layer Theory**, Mc Graw Hill, 1987

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FERZIGER, J., MILOVAN, P., **Computational Methods for fluid Dynamics**, Springer, 1999

---

F. Moukalled L. Mangani M. Darwish, **The Finite Volume Method in Computational Fluid Dynamics An Advanced Introduction with OpenFOAM® and Matlab®**, Springer, 2016

---

WILCOX, **Turbulence Modeling**, DCW Industries, 2004

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Stavros Tavoularis, **Measurement in Fluid Mechanics**, Cambridge University Press,, 2005

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GLASSMAN, **Combustion**, 4th edition, Elsevier, 2008

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[www.openfoam.org](http://www.openfoam.org),

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[www.openfoam.com](http://www.openfoam.com),

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### **Recommendations**

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#### **Other comments**

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Devote the time indicated for personal work, as well as use the personal tutorships with the professor to solve the possible doubts that arise during the personal work of the student.

It is recommended to study continuously from the very beginning of the subject as well as to maintain an active attitude in the classes.

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**IDENTIFYING DATA****Advanced fluid mechanics**

Subject	Advanced fluid mechanics			
Code	007M197V01201			
Study programme	(*)Máster Universitario en Enxeñería Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Navarro Medina, Fermín			
Lecturers	Navarro Medina, Fermín			
E-mail	fermin.navarro.medina@uvigo.es			
Web	http://aero.uvigo.es			
General description				

**Training and Learning Results**

Code	
A5	Understanding and mastery of atmospheric flight mechanics (performance, stability, static and dynamic control), orbital mechanics and attitude dynamics.

**Expected results from this subject**

Expected results from this subject	Training and Learning Results
Understanding and command of atmospheric flight mechanics (actions, stability, static and dynamic control), orbital mechanics and attitude dynamics.	A5

**Contents**

Topic	
1. Static stability and control of the aircraft	<ul style="list-style-type: none"> <li>- Brief review of static stability and static control of the aircraft.</li> <li>- Response of the aircraft to inputs on the aerodynamic controls.</li> <li>- Longitudinal static stability and control in manoeuvre</li> </ul>
2. Stability and dynamic control of the aircraft	<ul style="list-style-type: none"> <li>- Linearization of the general equations of the plane's motion.</li> <li>- Derivatives of longitudinal and lateral-directional stability.</li> <li>- Longitudinal and lateral-directional dynamic modes.</li> <li>- Dynamic stability and controllability in closed loop.</li> <li>- Flight qualities (FQ) and flight control systems (FCS).</li> </ul>
3. Orbital mechanics and attitude dynamics of space vehicles	<ul style="list-style-type: none"> <li>- Kinematics of rotational attitude</li> <li>- Attitude dynamics of rigid solid</li> <li>- Rotational maneuvers and attitude control</li> </ul>

**Planning**

	Class hours	Hours outside the classroom	Total hours
Case studies	12	62	74
Lecturing	29	0	29
Previous studies	0	30	30
Problem solving	4.5	0	4.5
Autonomous problem solving	0	10	10
Objective questions exam	1.5	0	1.5
Presentation	1	0	1

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

**Methodologies**

	Description
Case studies	Realization of practical case studies on the contents of the subject, which will be explained and started in the classroom to be finished and delivered by the students outside the classroom. The case studies will require the use of software.



Lecturing	Presentation of a topic or resolution of problems by the teaching staff according to a previously established script.
Previous studies	Students study autonomously, with the support of the teaching staff if required according to the procedures established by the university for tutorials
Problem solving	Resolution of problems and/or exercises that deal with specific aspects of the contents of the subject, developed by the teaching staff and/or the students in the classroom
Autonomous problem solving	Resolution of problems and/or exercises that deal with specific aspects of the contents of the subject, developed by the students outside the classroom

### Personalized assistance

#### Methodologies Description

Case studies	Realization of practical case studies on the contents of the subject, which will be explained and started in the classroom to be finished and delivered by the students outside the classroom. The students will have the necessary tutorials with the teaching staff to monitor the development of the case studies.
Previous studies	Support tutorials for students to study independently, according to the procedures established by the university.

### Assessment

	Description	Qualification	Training and Learning Results
Case studies	Four case studies to be carried out during the semester distributed over time, and software will be used for their resolution. The qualification of each of them will be 15%.	60	A5
Objective questions exam	Exam based on solving problems and/or conceptual questions about the contents of the subject. It will be on the official exam date. Minimum grade of 5.0.	35	A5
Presentation	Presentations of the results of the case studies to be carried out by the students throughout the course.	5	A5

### Other comments on the Evaluation

#### First call

To pass the subject on the 1st opportunity, it will be necessary to obtain a score of more than 5 points out of 10 in the joint evaluation of the continuous evaluation during the development of the classes and the exam on the official date. In addition, the exam grade on the official date must be greater than or equal to 5 points out of 10. The final grade of the continuous assessment will be obtained according to the indicated percentages.

For the global evaluation, an exam will be carried out on the day of the official date, which includes all the contents of the subject, including the contents and methods used in the case studies. The qualification of said exam to pass the subject will be 5 points out of 10.

The evaluation test schedule officially approved by the Junta de Centro da EEAE is published on the web

<http://aero.uvigo.es/gl/docencia/exames>

Continuous assessment tests will be carried out during school hours"

The student has the right to opt for the global assessment according to the procedure and the deadline established by the centre for each call.

#### Second call

The student must take the second call exam of all the contents of the subject, which will mean 100% of the grade, if the final continuous assessment grade is less than 5 points out of 10. They will also have to sit the second call exam in the following cases:

- Obtain a grade of less than 5 points out of 10 in the first chance final exam

In case of obtaining a grade greater than or equal to 5 in the second chance exam, the final grade for the subject will be the highest grade between:

\* the 2nd call exam

\* the average with the activities carried out during the course (averaging with the percentages of the evaluation table

substituting the mark of the first call exam for the second call)

### **End-of-program call**

For the end of degree evaluation, an exam will be held on the day of the official date, which includes all the contents of the subject. The qualification of said exam to pass the subject will be 5 points out of 10.

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### **Sources of information**

#### **Basic Bibliography**

Gómez Tierno M.A., Pérez Cortés M., Puentes Márquez C, **Mecánica del vuelo**, 978-84-15452-01-0, 2, Ibergarceta Publicaciones, 2012

#### **Complementary Bibliography**

Bong Wie, **Space Vehicle Dynamics and Control**, 978-1-56347-953-3, 2, American Institute of Aeronautics and Astronautics, 2008

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### **Recommendations**

#### **Subjects that it is recommended to have taken before**

Advanced aerodynamics and aeroelasticity/O07M197V01101

**IDENTIFYING DATA****Advanced calculation of aerospace structures**

Subject	Advanced calculation of aerospace structures			
Code	O07M197V01202			
Study programme	(*)Máster Universitario en Enxeñaría Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Gómez San Juan, Alejandro Manuel			
Lecturers	Gómez San Juan, Alejandro Manuel			
E-mail	alejandromanuel.gomez@uvigo.es			
Web				
General description	In the subject "Advanced calculation of aerospace structures" we start from the more general knowledge acquired in the degree about the functioning of structures, to specify structures for aerospace use, which have requirements that differentiate them from other structures. After completing the course, the student should be able to design and analyze the combinations of structures and materials in the most common boundary conditions in the industry.			

**Training and Learning Results**

Code	
A1	Ability to design, build, inspect, certify and maintain all types of aircraft and spacecraft
A6	Adequate knowledge of metallic and composite materials used in aerospace vehicle manufacturing
A8	Knowledge and skills for the structural analysis and design of aircraft and spacecraft, including the application of advanced structural design and calculation programs

**Expected results from this subject**

Expected results from this subject	Training and Learning Results
G01. Aptitude to project, build, inspect, certify and keep all type of aircraft and space vehicles.	A1
G06. Suitable knowledge of the metallic materials and compound materials used in the manufacture of aerospace vehicles.	A6
G08. Knowledges and capacities for the analysis and structural design of the aircraft and space vehicles, including the application of programs of calculation and design advanced of structures.	A8

**Contents**

Topic	
Types of aerospace structures	-Typologies of structures -Structures of aeronautical use -Structures of space use
Types of structural analysis	-Static analysis -Dynamic Analysis -Analysis stability
Materials for aerospace use	-Linear elastic materials -Non-linear elastic materials -Plastic materials -Visco-elastic materials
Multidisciplinary analysis and optimisation	-Multidisciplinary analysis joined up -Optimisation of structures

**Planning**

	Class hours	Hours outside the classroom	Total hours
Lecturing	29	29	58
Practices through ICT	15.5	0	15.5
Case studies	1	73	74
Objective questions exam	2.5	0	2.5

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

<b>Methodologies</b>	
	Description
Lecturing	Exhibition by part of the professor of the contents on the matter object of study, theoretical bases and guidelines of a work or exercise that the/the student has to develop.
Practices through ICT	Activities of application of the knowledges in a determinate context and of acquisition of basic skills and procedures in relation with the matter, through the TIC, fundamentally with tools of simulation used in the industry.
Case studies	Realisation of cases of practical study on the contents of the subject, the which will be explained and initiated in the classroom to be finished and delivered by part of the students out of the classroom. The cases of study will require of the use of specific software

### **Personalized assistance**

<b>Methodologies</b>	<b>Description</b>
Case studies	Realisation of cases of practical study on the contents of the subject, the which will be explained and initiated in the classroom to be finished and delivered by part of the students out of the classroom. The students will have of the personal lessons necessary with the professor for the follow-up of the development of the cases of study

<b>Assessment</b>			
	Description	Qualification Training and Learning Results	
Objective questions exam	Examination based in the resolution of problems and/or conceptual questions on the contents of the subject. It will be in date of official examination. Minimum note of 5.0.	40	A1 A6 A8

### **Other comments on the Evaluation**

#### **First Opportunity Evaluation**

To pass the subject on the 1st opportunity, it will be necessary to obtain a grade higher than 5 points out of 10 in the overall assessment of continuous evaluation during the course and the exam on the official date. Additionally, the grade for the official exam must be equal to or higher than 5 points out of 10. The final grade for continuous evaluation will be obtained according to the indicated percentages.

For the overall evaluation, there will be an exam on the official date, which includes all the contents of the subject, including the contents and methods used in the case studies. The passing grade for this exam will be 5 points out of 10.

The officially approved schedule of evaluation tests by the EEAE Center Board will be published on the website:

<http://aero.uvigo.es/gl/docencia/exames>

The continuous evaluation tests will be conducted during regular class hours.

The student has the right to choose the overall evaluation according to the procedure and deadline established by the institution for each examination session.

#### **Second Opportunity Evaluation**

Students must take the resit exam, which covers all the subject contents and accounts for 100% of the final grade, if the final grade for continuous evaluation is lower than 5 points out of 10. They must also take the resit exam in the following cases:

- Obtaining a grade lower than 5 points out of 10 in the final exam of the first opportunity.

If a grade equal to or higher than 5 is obtained in the resit exam, the final grade for the subject will be the higher grade between:

- the resit exam grade,
- the average grade from the coursework activities (averaging with the percentages specified in the evaluation table, substituting the grade of the first opportunity exam with the grade of the resit exam).

## Final Year Evaluation

For the final year evaluation, there will be an exam on the official date, which includes all the contents of the subject. The passing grade for this exam will be 5 points out of 10.

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### Sources of information

#### Basic Bibliography

#### Complementary Bibliography

T. H. G. Megson, **Aircraft Structures for Engineering Students**, 978-0081009147, 6, Butterworth-Heinemann, 2016

D. J. Peery, **Aircraft Structures**, 978-0486485805, Dover Publications, 2011

Bruhn, **Analysis and Design of Flight Vehicle Structures**, 978-0961523404, Jacobs Pub, 1973

M. Niu, **Airframe Structural Design: Practical Design Information and Data on Aircraft Structures**, 978-9627128045, 1988

J. Wijker, **Spacecraft Structures**, 978-3540755524, Springer, 2008

V.P Singh, **Mechanical Vibrations**, Dhanpat Rai, 2014

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### Recommendations

#### Subjects that are recommended to be taken simultaneously

Advanced fluid mechanics/O07M197V01201

#### Subjects that it is recommended to have taken before

Advanced aerospace materials and production/O07M197V01102

#### Other comments

Given the absence of the subject of Vibrations in one of the two intensifications of the degree we recommend to the students that do not have it passed the study of the concepts that are given in the said subject. In particular the book Mechanical Vibrations included in the bibliography recommended constitutes a good introduction.

**IDENTIFYING DATA****Design, calculation and certification of aerospace propulsion systems**

Subject	Design, calculation and certification of aerospace propulsion systems			
Code	O07M197V01203			
Study programme	(*)Máster Universitario en Enxeñaría Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Gómez San Juan, Alejandro Manuel			
Lecturers	Gómez San Juan, Alejandro Manuel			
E-mail	alejandromanuel.gomez@uvigo.es			
Web				
General description	In this subject the main aim is to develop the capacity to design and calculate performances of jet engines and their components.			

**Training and Learning Results**

Code	
A11	Ability to design, build and select the most suitable power plant for an aerospace vehicle, including self-derived power plants
A16	Adequate knowledge of aerjets, gas turbines, rocket engines and turbomachines.
A17	Ability to undertake the mechanical design of different components of a propulsion system, as well as the propulsion system as a whole.
A18	Ability to design, execute and analyze propulsion system tests, and to carry out the complete propulsion system certification process.
A19	Adequate knowledge of the different subsystems of aerospace vehicle propulsion plants.

**Expected results from this subject**

Expected results from this subject	Training and Learning Results
GO11. Aptitude to project, build and select the plant of power more adapted for an aerospace vehicle, including the plants of power autoderivated.	A11
GO16. Know adapted of jet engines, turbines of gas, engines rocket and turbomachinery.	A16
GO17. Capacity to tackle the mechanical design of distinct components of a propulsive system, as well as of the system propulsive in his group.	A17
GO18. Capacity to design, execute and analyse the essays of propulsive systems , and to carry out the complete process of certification of the same..	A18
GO19. Suitable knowledge of the distinct subsystems of the propulsive plants of aerospace vehicles.	A19

**Contents**

Topic	
Performances of jet engines	-Global performances: biaxial, turbofans, -Performances of components: takings, compressors, cameras of combustion, turbines, nozzles -Non- steady state performances
Essays and material	-Banks of essays -Calculation of the no measured parameters -Models pre-essay -Material used in jet engines
Multidisciplinary appearances of propulsive systems	-Interaction with other subsystems -objective Functions -Application to the design of systems of control -Other appearances to consider
Technicians of simulation	-Types of models of jet engines -Decomposition of systems -Levels of fidelity

<b>Planning</b>			
	Class hours	Hours outside the classroom	Total hours
Lecturing	29	30	59
Problem solving	16.5	40	56.5
Mentored work	0	32	32
Essay questions exam	2	0	2
Essay	0.5	0	0.5

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

<b>Methodologies</b>	
	Description
Lecturing	Exhibition by part of the professor of the contents on the matter object of study, theoretical bases and guidelines of a work or exercise that the/the student has to develop.
Problem solving	Activity in which they formulate problems and /or exercises related with the matter. The student has to develop the suitable solutions by means of the exertion of routines, the application of formulas or algorithms, the application of procedures of transformation of the available information and the interpretation of the results. It is used to employ as I complement of the theoretical lesson
Mentored work	Activity in which they formulate a problem of design related with the matter. The student has to develop by his account the suitable solutions by means of the exertion of routines, the application of formulas or algorithms. At the end of the course has to present the work in class

<b>Personalized assistance</b>	
Methodologies	Description
Problem solving	Realisation of practical problems on the contents of the subject, the which will be explained and initiated in the classroom to be finished and delivered by part of the students out of the classroom. The students will have of the personal lessons necessary with the professor for the follow-up of the development of the cases of study
Mentored work	Realisation of a work on the contents of the subject, the which will be explained and initiated in the classroom to be finished and delivered by part of the students out of the classroom. The students will have of the personal lessons necessary with the professor for the follow-up of the development of the cases of study

<b>Assessment</b>			
	Description	Qualification	Training and Learning Results
Essay questions exam	(*)Dous exames baseados na resolución de problemas e/ou preguntas conceptuais sobre os contidos da materia. O primeiro realizarase en clase e o segundo será en data de exame oficial. Nota mínima de 5.0. Cada exame valerá o 40% da nota final.	80	A11 A16 A17 A18 A19
Essay	(*)Traballo que consiste no deseño dun sistema de propulsión cos conceptos apresos na materia e con presentación en clase	20	A11 A16 A17 A18 A19

### **Other comments on the Evaluation**

#### First Opportunity Evaluation

To pass the subject on the 1st opportunity, it will be necessary to obtain a grade higher than 5 out of 10 in the overall assessment of continuous evaluation during the course and the exam on the official date. Additionally, the grade for the official exam must be equal to or higher than 5 out of 10. The final grade for continuous evaluation will be determined according to the indicated percentages.

For the overall evaluation, there will be an exam on the official date, which includes all the contents of the subject, including the contents and methods used in the coursework. The passing grade for this exam will be 5 out of 10.

The officially approved schedule of evaluation tests by the EEAE Center Board will be published on the website:

<http://aero.uvigo.es/en/docencia/exams>

The continuous evaluation tests will be conducted during regular class hours.

Students have the right to choose the overall evaluation procedure and deadline set by the institution for each examination session.

#### Second Opportunity Evaluation

Students must take the resit exam, which covers all the subject contents and accounts for 100% of the final grade, if the final grade for continuous evaluation is lower than 5 out of 10. They must also take the resit exam in the following cases:

- Obtaining a grade lower than 5 out of 10 in the final exam of the first opportunity.

If a grade equal to or higher than 5 is obtained in the resit exam, the final grade for the subject will be the higher grade between:

- The resit exam grade.
- The average grade from the coursework activities (taking into account the percentage distribution specified in the evaluation table, substituting the grade of the first opportunity exam with the grade of the resit exam).

#### Final Year Evaluation

For the final year evaluation, there will be an exam on the official date, covering all the subject contents. The passing grade for this exam will be 5 out of 10.

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#### Sources of information

##### Basic Bibliography

##### Complementary Bibliography

J.L Kerrebrock, **Aircraft Engines and Gas Turbines**, 978-0262534031, 2, MIT Press, 1992

G. Sutton, **Rocket Propulsion Elements**, 978-1118753651, 9, Wiley, 2016

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#### Recommendations

#### Subjects that it is recommended to have taken before

Design, calculation and certification of aircraft and space vehicles/O07M197V01103



**IDENTIFYING DATA****Advanced air navigation systems**

Subject	Advanced air navigation systems			
Code	O07M197V01204			
Study programme	(*)Máster Universitario en Enxeñería Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	González Jorge, Higinio			
Lecturers	González Jorge, Higinio			
E-mail	higiniog@uvigo.gal			
Web	http://aero.uvigo.es			
General description	The course provides a fundamental vision of air navigation and circulation. Its objective is to describe how the information obtained by different sensors is used to allow safe and efficient air navigation.			

**Training and Learning Results**

Code	
A20	Ability to define and design air traffic navigation and management systems, to design airspace, maneuvers and aeronautical easements.
A21	Adequate knowledge of avionics and on-board software, simulation and control techniques used in air navigation.
A22	Adequate knowledge of wave propagation and the problems of links with ground stations.
A23	Ability to design RADAR systems and air navigation aids.
A25	Adequate knowledge of the different regulations applicable to air navigation and air traffic, as well as the ability to certify air navigation systems.
A33	Competence to plan, design, manage and certify the procedures, infrastructures and systems that support aerospace activities, including air navigation systems.

**Expected results from this subject**

Expected results from this subject	Training and Learning Results
Ability to define and design air traffic navigation and management systems, to design airspace, maneuvers and aeronautical easements	A20
Adequate knowledge of avionics and on-board software, simulation and control techniques used in air navigation	A21
Adequate knowledge of wave propagation and the problems of links with ground stations	A22
Ability to design RADAR systems and air navigation aids	A23
Adequate knowledge of the different regulations applicable to air navigation and air traffic, as well as the ability to certify air navigation systems	A25
Competence to plan, design, manage and certify the procedures, infrastructures and systems that support aerospace activities, including air navigation systems	A33

**Contents**

Topic
1. Introduction to Navigation. Aeronautical cartography. Reference system WGS84 linked to Earth.
2. Positioning by situation surfaces based on radio beacons. VOR, ILS, DME systems.
3. Satellite positioning. GPS, GLONASS, GALILEO systems. ADSB system.
4. Inertial measurement systems.
5. Algoritmos de estimación de la posición. Filtro de Kalman.
6. Airspace organization and design. Flow and separation management.
7. CNS/ATM systems. Regulations, definition of operational requirements, operation and maintenance.

<b>Planning</b>			
	Class hours	Hours outside the classroom	Total hours
Lecturing	29	0	29
Laboratory practical	16.5	0	16.5
Mentored work	0	102	102
Objective questions exam	1.25	0	1.25
Objective questions exam	1.25	0	1.25

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

<b>Methodologies</b>	
	Description
Lecturing	Exposure of the contents of the subject through audiovisual media.
Laboratory practical	Troubleshooting using software tools.
Mentored work	The student will carry out a project based on technical specifications defined by the professor.

<b>Personalized assistance</b>	
Methodologies	Description
Lecturing	Classroom attention. Tutorials with previous appointment. Attention by email. Mail: higiniog@uvigo.gal
Laboratory practical	Classroom attention. Tutorials with previous appointment. Attention by email. Mail: higiniog@uvigo.gal
Mentored work	Tutorials with previous appointment. Attention by email. Mail: higiniog@uvigo.gal

<b>Assessment</b>			
	Description	Qualification	Training and Learning Results
Laboratory practical	Laboratory report	15	A20 A21 A22 A23 A25 A33
Mentored work	Project	15	A20 A21 A22 A23 A25 A33
Objective questions exam	Partial exam I	35	A20 A21 A22 A23 A25 A33
Objective questions exam	Partial exam II	35	A20 A21 A22 A23 A25 A33

### **Other comments on the Evaluation**

The student has the right to opt for the global assessment according to the procedure and the deadline established by the centre for each call.

The continuous assessment will be carried out during university class hours.

The official exam dates are used for the student to take an exam-only assessment of the course if he/she does not follow the continuous assessment or fails it. This exam will correspond to 100% of the course and will have a duration of 2.5 hours.

No marks for each of the parts will be kept between different exam sessions.

The calendar of evaluation tests officially approved by the Faculty is published on the web page:

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**Sources of information**

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**Basic Bibliography**

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Francisco Javier Sáez Nieto, **Navegación aérea: Posicionamiento, Guiado y Gestión del Tráfico Aéreo**, 8415452314, Ibergarceta Publicaciones S.L., 2012

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**Complementary Bibliography**

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Luis Pérez Sanz et al., **Introducción al sistema de navegación aérea**, 8415452810, Ibergarceta Publicaciones S.L., 2013

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**Recommendations**

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**Subjects that are recommended to be taken simultaneously**

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Avionics/O07M197V01205

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<b>IDENTIFYING DATA</b>				
<b>Avionics</b>				
Subject	Avionics			
Code	O07M197V01205			
Study programme	(*)Máster Universitario en Enxeñería Aeronáutica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	González Jorge, Higinio			
Lecturers	González Jorge, Higinio			
E-mail	higiniog@uvigo.gal			
Web	http://aero.uvigo.es			
General description	This course aims to teach students the main electronic systems present in an aircraft, both in terms of communication and navigation systems.			

<b>Training and Learning Results</b>	
Code	
A21	Adequate knowledge of avionics and on-board software, simulation and control techniques used in air navigation.
A22	Adequate knowledge of wave propagation and the problems of links with ground stations.
A23	Ability to design RADAR systems and air navigation aids.
A24	Adequate knowledge of aeronautical information technologies and communications.

<b>Expected results from this subject</b>	
Expected results from this subject	Training and Learning Results
Adequate knowledge of avionics and on-board software, simulation and control techniques used in air navigation	A21
Adequate knowledge of wave propagation and the problems of links with ground stations	A22
Ability to design RADAR systems and air navigation aids	A23
Adequate knowledge of aeronautical information technologies and communications	A24

<b>Contents</b>	
Topic	
1.	Introduction and specific problems in on-board equipment.
2.	Noise and interference. EM compatibility. Optical and optoelectronic solutions.
3.	Power supply systems. Requirements and structures.
4.	Sensors, actuators and other input and output devices.
5.	Electronic signal collection and delivery and preprocessing.
6.	Baseband signal transmission. ARINC and MIL buses.
7.	Information processing and on-board software. Simulation and Control Techniques.

<b>Planning</b>			
	Class hours	Hours outside the classroom	Total hours
Lecturing	29	0	29
Laboratory practical	16.5	0	16.5
Mentored work	0	102	102
Objective questions exam	1.25	0	1.25
Objective questions exam	1.25	0	1.25

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## **Methodologies**

	Description
Lecturing	Exposure of the contents of the course through audiovisual media.
Laboratory practical	Troubleshooting through laboratory assemblies.
Mentored work	The student will carry out a project based on technical specifications defined by the professor.

### Personalized assistance

Methodologies	Description
Lecturing	Classroom attention. Tutorials with previous appointment. Attention by email. Mail: higiniog@uvigo.gal
Laboratory practical	Classroom attention. Tutorials with previous appointment. Attention by email. Mail: higiniog@uvigo.gal
Mentored work	Tutorials with previous appointment. Attention by email. Mail: higiniog@uvigo.gal

### Assessment

	Description	Qualification	Training and Learning Results
Laboratory practical	Laboratory report	10	A21 A22 A23 A24
Mentored work	Project	30	A21 A22 A23 A24
Objective questions exam	Partial exam I	30	A21 A22 A23 A24
Objective questions exam	Partial examn II	30	A21 A22 A23 A24

### Other comments on the Evaluation

The student has the right to opt for the global assessment according to the procedure and the deadline established by the centre for each call.

The continuous assessment will be carried out during university class hours.

The official exam dates are used for the student to take an exam-only assessment of the course if he/she does not follow the continuous assessment or fails it. This exam will correspond to 100% of the course and will have a duration of 2.5 hours.

No marks for each of the parts will be kept between different exam sessions.

The calendar of evaluation tests officially approved by the Faculty is published on the web page:

<http://aero.uvigo.es/es/docencia/examenes/>

### Sources of information

#### Basic Bibliography

Jesús Martínez Rueda, **Aviónica básica en aeronaves**, 9788428341158, Ediciones Paraninfo, 2021

Ian Moir, Allan Seabridge, **Aircraft Systems: Mechanical, electrical, and avionics subsystems integration**, 9780470770931, John Wiley & Sons, Ltd, 2008

R.P.G. Collinson, **Introduction to Avionics Systems**, 978-94-007-0708-5, Elsevier, 2011

#### Complementary Bibliography

### Recommendations

#### Subjects that are recommended to be taken simultaneously

Advanced air navigation systems/O07M197V01204