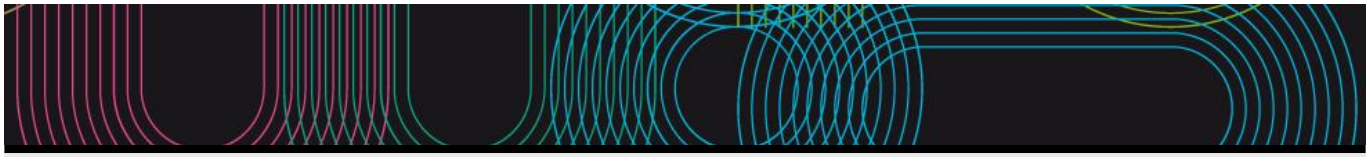

# (*)Escola de Enxeñaría Aeronáutica e do Espazo

## 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

Escola de Enxeñaría Aeronáutica e do Espazo

Pavillón Manuel Martínez-Risco
Campus universitario
32004 Ourense

Tel.: +34 988 368 823
Web: http://aero.uvigo.es

## 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 Enxeñería Aeronáutica

## Subjects

### Year 1st

| Code | Name | Quadmester | Total Cr. |
|---|---|---|---|
| O07M197V01101 | Advanced aerodynamics and aeroelasticity | 1st | 6 |
| O07M197V01102 | Advanced aerospace materials and production | 1st | 9 |
| O07M197V01103 | Design, calculation and certification of aircraft and space vehicles | 1st | 9 |
| O07M197V01104 | Advanced fluid mechanics | 1st | 6 |
| O07M197V01201 | Flight dynamic | 2nd | 6 |
| O07M197V01202 | Advanced calculation of aerospace structures | 2nd | 6 |
| O07M197V01203 | 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://webs.uvigo.es/muea | | | |
| 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 aircraft flight. 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 | |
| B2 | Understanding and mastering the laws of external aerodynamics in different flight regimes, and application to numerical and experimental aerodynamics |
| C1 | Ability to design, execute and analyze ground and flight tests of aerospace vehicles, and to carry out a complete aerospace vehicle certification process. |
| D2 | Application of knowledge acquired in different disciplines to solve complex aeroelasticity problems |
| D5 | 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 | Training and Learning Results |
|---|---|
| ID3. Understanding and mastery of the laws of external aerodynamics in the different flight regimes, and application to numerical aerodynamics and experimental. | B2 |
| ID4. Application of the knowledge acquired in different disciplines to the resolution of complex aeroelasticity problems. | D2 |
| ID9. Ability to design, execute and analyze ground and flight tests of aerospace vehicles, and to carry out a process of complete certification. | C1 |
| ID14. Understanding and mastery of the laws of internal aerodynamics, as well as application together with other disciplines, to the resolution of complex problems of aeroelasticity and propulsion systems | D5 |

| Contents | |
|---|---|
| Topic | |
| 1. Subsonic aerodynamics | o Potential theory of wings in a subsonic compressible regime.<br>o Subsonic and supersonic air intakes.<br>o Numerical techniques of whirlwind methods.<br>o Experimental techniques (wind tunnels, instrumentation and test techniques). |
| 2. Supersonic aerodynamics | o Transonic phenomena in profiles and wings.<br>o Supersonic wing power theory.<br>o Potential theory of slender bodies.<br>o Subsonic and supersonic air intakes.<br>o Hypersonic regime |
| 3. Static aeroelasticity | o Continuous systems and discrete systems. Forced vibrations of continuous systems.<br>o Approximate methods for solving continuous systems. Static aeroelasticity of the wings. Divergence and reversal of command. |

| | |
|---|---|
| 4. Dynamic aeroelasticity | o Dynamic aeroelasticity of wings.<br>o Advanced aeroelasticity. Aeroelasticity in the Laplace domain. Nonlinear aeroelasticity. Aeroservoelasticity.<br>o Structural dynamics and aeroelasticity tests. Aeroelastic tests in flight. |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Case studies | 12 | 62 | 74 |
| 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. |
| 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 | B2 | C1 | D2<br>D5 |
| 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 | B2 | C1 | D2<br>D5 |
| Presentation | Presentations of the results of the case studies to be carried out by the students throughout the course. | 5 | B2 | C1 | D2<br>D5 |

**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.

## Sources of information

### Basic Bibliography

A. Barrero Ripoll, **Aerodinámica de altas velocidades**, Garceta Grupo Editorial, 2011

### Complementary Bibliography

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

John J. Bertin, Russell M. Cummings, **Aerodynamics for engineers**, ISBN-10: 0-13-235521-3, Pearson Prentice-Hall, 2009

## Recommendations

### Subjects that continue the syllabus

Flight dynamic/O07M197V01201

### Subjects that are recommended to be taken simultaneously

Advanced fluid mechanics/O07M197V01104

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Materiais e producción aeroespacial avanzados** | | | | |
| Subject | Materiais e producción 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 | Deseño na enxeñaría<br>Enxeñaría dos materiais, mecánica aplicada e construción | | | |
| Coordinator | Álvarez González, David<br>Carou Porto, Diego | | | |
| Lecturers | Álvarez González, David<br>Carou Porto, Diego | | | |
| E-mail | davidag@uvigo.es<br>diecapor@uvigo.es | | | |
| Web | http://webs.uvigo.es/muea | | | |
| General description | Asignatura de materiais avanzados para a industria aeroespacial e producción. | | | |

| Resultados de Formación e Aprendizaxe | |
|---|---|
| Code | |
| B3 | Coñecemento adecuado dos materiais metálicos e materiais compostos utilizados na fabricación de vehículos aeroespaciais |
| B4 | Coñecementos e habilidades que permitan comprender e levar a cabo os procesos de fabricación de vehículos aeroespaciais |
| B8 | 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 |
| ID 6 Coñecemento axeitado dos materiais metálicos e materiales compostos empregados na fabricación de vehículos aeroespaciales<br><br>ID7 Coñecemento e capacidades que permiten comprender e realizar os procesos de fabricación dos vehículos aeroespaciais.<br><br>ID15 Coñecemento axeitado dos materiais e procesos de fabricación empregados nos sistemas de propulsión | B3<br>B4<br>B8 |

| Contidos |
|---|
| Topic |

| | |
|---|---|
| Bloque Materiais | 1. Criterios de selección e comportamento en servizo dos materiais aeroespaciais.<br>-Introdución á selección de materiais.<br>-Parámetros de deseño.<br>-Propiedades mecánicas , térmicas, eléctricas, resistencia ao medio.<br><br>2. Materiais metálicos avanzados para estruturas aeronáuticas.<br>-Aliaxes de aluminio avanzadas.<br>-Aceiros inoxidables avanzados.<br>-Materiais compostos matriz polimérica.<br><br>3. Materiais metálicos avanzados para sistemas propulsivos aeronáuticos e espaciais.<br>-Aliaxes de Titanio<br>-Superaleaciones<br>-Cerámicos<br>-Materiais compostos de matriz cerámica<br><br>4. Análise de Fallos en Servizo<br>-Resistencia a corrosión<br>-Termofluencia<br>-Fractografía<br>-Fatiga |
| Bloque Produción | 1. Introdución<br>2. Procesos de mecanizado non convencional<br>3. Micromecanizado<br>4. Fabricación aditiva de materiais compostos<br>5. Procesos de acabado e tratamento superficial<br>6. Introdución a sistemas de produción<br>7. Economía da fabricación<br>8. Equilibrado de liñas<br>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 | B3<br>B4<br>B8 |
| Prácticas de laboratorio | Entrega de informes | 15 | B3<br>B4<br>B8 |
| Prácticas con apoio das TIC | Entrega de informes | 15 | B3<br>B4<br>B8 |
| Traballo tutelado | Entrega de memorias e realización de presentacións | 25 | B3<br>B4<br>B8 |
| Exame de preguntas obxectivas | Cuestionario | 35 | B3<br>B4<br>B8 |

**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 3,5 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, desenvolvemento e/ou resposta curta.

-Resolución de problemas (nota máxima 1 punto). Avaliarase a entrega da resolución aos problemas expostos durante o curso nos prazos establecidos.

-Prácticas de laboratorio (nota máxima 1,5 puntos). Deberase participar nas actividades propostas durante o curso e entregar os informes requiridos.

-Prácticas con apoio do TIC (nota máxima 1,5 puntos). Deberase participar nas actividades propostas durante o curso e entregar os informes requiridos.

-Traballo tutelado (nota máxima 2,5 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 evaluación fin de carreira seguirá os mesmos criterios ca evaluación de 2ª oportunidade.

| Bibliografía. Fontes de información |
|---|
| **Basic Bibliography** |
| Mikell P. Groover, **Automation, production systems, and computer-integrated manufacturing**, Pearson, 2016 |
| Lee Harper, Mike Clifford (EDITORS), **Design and Manufacture of Structural Composites**, Elsevier, 2022 |
| Abdel Salam Hamdy Makhlouf y Mahmood Aliokhazraei (edited), **Handbook of materials failure analysis with case studies from the aerospace and automotive industries**, 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 |

| 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 Enxeñería 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 | http://webs.uvigo.es/muea | | | |
| General description | The subject "Design, calculation, and certification of aircraft and spacecraft" is a discipline of applied engineering. It utilizes the knowledge acquired in the degree to address the initial phase of conceptual design according to design requirements, and the two phases of design validation, calculation, and validation/certification. In the first block of the subject, this process is followed for aircraft, and in the second for spacecraft.<br>English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| B5 | Knowledge and skills for the structural analysis and design of aircraft and spacecraft, including the application of advanced structural design and calculation programs |
| B6 | Adequate knowledge of the different subsystems of aircraft and spacecraft |
| C1 | Ability to design, execute and analyze ground and flight tests of aerospace vehicles, and to carry out a complete aerospace vehicle certification process. |
| D1 | Ability to design, build, inspect, certify and maintain all types of aircraft and spacecraft |
| D3 | Understanding and mastery of atmospheric flight mechanics (performance, stability, static and dynamic control), orbital mechanics and attitude dynamics. |

| 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 | D1 |
| 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. | D3 |
| 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 | B5 |
| 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. | C1 |
| GO10. Suitable knowledge of the distinct subsystems of the aircraft and space vehicles. | B6 |

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

| | |
|---|---|
| Space vehicles: requirements and preliminary design | -Space missions<br>-Surroundings of operation and development<br>-Orbit<br>-Geometry of space missions |
| Space vehicles: conceptual design and architecture | -Subsystems of space vehicles<br>-Power<br>-Structure<br>-thermal Control<br>-AOCS<br>-Communications |
| Space vehicles: verification and essays | -Guarantee of product<br>-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 | B5<br>B6 | C1 | D1<br>D3 |
| 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 | B5<br>B6 | C1 | D1<br>D3 |

**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.

| **Sources of information** |
|---|
| **Basic Bibliography** |
| **Complementary Bibliography** |
| J. Anderson, **Aircraft Performance & Design**, 1, McGraw-Hill Education, 1988 |
| D. P. Reymer, **Aircraft Design: A Conceptual Approach**, 6, American Institute of Aeronautics & Ast., 2018 |
| P. Fortescue, **Spacecraft Systems Engineering**, 3, Wiley, 2003 |
| W. Larson, J. Wertz, **Space Mission Analysis and Design**, 3, Springer, 1999 |

| **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 |

| 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 | #EnglishFriendly Spanish | | | |
| Department | | | | |
| Coordinator | Martín Ortega, Elena Beatriz | | | |
| Lecturers | Martín Ortega, Elena Beatriz | | | |
| E-mail | emortega@uvigo.es | | | |
| Web | http://webs.uvigo.es/muea | | | |
| General description | Subject that includes advanced knowledge of fluid flows, from a theoretical and numerical perspective, including also reactive flows.<br><br>English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| B1 | Adequate knowledge of advanced fluid mechanics, with special emphasis on computational fluid mechanics and turbulence phenomena |
| B7 | Adequate knowledge of advanced fluid mechanics, with special emphasis on experimental and numerical techniques used in fluid mechanics. |
| D4 | Understanding and mastering the phenomena associated with combustion and heat and mass transfer. |

| Expected results from this subject | Training and Learning Results |
|---|---|
| Know how to analyse flows (both incompresible and compressible flows, including flows with combustion) by means of Computational Dynamics Techniques<br><br>In this subject, we will focus on:<br>- using numerical and/or analytical methods to solve a fluid flow problem<br>- Working by projects | B1<br>B7<br>D4 |
| ID2. Adequate knowledge of advanced fluid mechanics, with special emphasis on computational fluid mechanics and turbulence phenomena. | B1 |
| ID 12 Adequate knowledge of advanced fluid mechanics, with special emphasis on experimental and numerical techniques used in fluid mechanics. | B7 |
| ID 13 Understanding and mastering the phenomena associated with combustion and heat and mass transfer. | D4 |

| Contents | |
|---|---|
| Topic | |
| 1. REVISION OF NAVIER-STOKES EQUATIONS | 1.1. Principles of conservation of mass, linear momentum and energy.<br>1.2. Euler Equations.<br>1.3. Initial and boundary condiitions<br>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<br>2.2. Integral equation of Karman.<br>2.3. Blausius Solution. Effects of suction/blown.<br>2.4. Solutions of Falkner-Skan.<br>2.5. Thermal boundary layer<br>2.6. Effects of compressibility. Boundary layers at very high speed |

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

| **Planning** | | | |
|---|---|---|---|
| | 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. | | | |

| **Methodologies** | |
|---|---|
| | 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 partical 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 |

| **Personalized assistance** | |
|---|---|
| **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 personaly 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 personaly during the subject tutorships. |
| Mentored work | Students will be attended personaly during the subject tutorships. |
| Problem solving | Students will be attended personaly during the subject tutorships. |

## Assessment

| | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Mentored work | Evaluation task in which the student solves numerically a specific flow problem asigned by the professor. The student will analyse it and will resolve the problem using the numerical techniques. The work will be uploaded to the Moovi platform befor the oficial date of the exam | 40 | B1<br>B7 | D4 |
| Problem solving | Relization of two examinations. These exams can include enclosed questions with different alternative of answer (true/false, multiple election, pairing of elements...), or the application of the knowledge to the resolution of specific problems of fluids, or the realisation of a work of numerical simulation nature. Each one of the examinatiions will have a weight of 30% on the final note of the subject. One of these two exams will take place in the oficial final exam date | 60 | B1<br>B7 | D4 |

## 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/tests/projects done during the continuous assesment 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 (that will take place during the official date marked by the school), which 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 at the oficial school web page

**Second opportunity evaluation:**

if the final note of the continuous assessment papers/tests/projects done during the teaching period is lower that 5 points over 10, the students will take an exam that includes all the contents os the course, which will have a weight of 100% of the final mark of the course.

In the case of having a score equal to or higher than 5 out of 10 in the continuous assessment papers/tests/projects, the mark will be kept for the second opportunity, having to take only the official exam, which will have a weight of 30% of the final mark of the course.

**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 the contents of the course. 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**, 3nd 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**

SCHLICHTING, H,, **Boundary Layer Theory**, Mc Graw Hill, 1987
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
Stavros Tavoularis, **Measurement in Fluid Mechanics**, Cambridge University Press,, 2005
GLASSMAN, **Combustion**, 4th edition, Elsevier, 2008
www.openfoam.org,
www,openfoam.com,

## Recommendations

### Other comments

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 continuosly from the very beginning of the subject as well as to mantain an active attitude in the classes.

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Flight dynamic** | | | | |
| Subject | Flight dynamic | | | |
| Code | O07M197V01201 | | | |
| 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://muea.webs.uvigo.es | | | |
| General description | The study of the equations of the dynamic motion of aircraft and space vehicles is addressed. As a previous step, the static stability and control of the airplane is studied, in straight flight and maneuver. Subsequently, the dynamic equations of motion are analyzed: linearizing them, obtaining the derivatives of longitudinal and lateral-directional stability, the modes of the airplane, and the stability and control in open and closed loop. Finally, an introduction is made to the attitude dynamics of space vehicles, their equations and applied to orientation control maneuvers. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| D3 | 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. | D3 |

| Contents | |
|---|---|
| Topic | |
| 1. Static stability and control of the aircraft | - Brief review of static stability and static control of the aircraft.<br>- Response of the aircraft to inputs on the aerodynamic controls.<br>- Longitudinal static stability and control in manoeuvre |
| 2. Stability and dynamic control of the aircraft | - Linearization of the general equations of the plane's motion.<br>- Derivatives of longitudinal and lateral-directional stability.<br>- Longitudinal and lateral-directional dynamic modes.<br>- Dynamic stability and controllability in closed loop.<br>- Flight qualities (FQ) and flight control systems (FCS). |
| 3. Orbital mechanics and attitude dynamics of space vehicles | - Kinematics of rotational attitude<br>- Attitude dynamics of rigid solid<br>- Rotational maneuvers and attitude control |

| 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 | D3 |
| 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 | D3 |
| Presentation | Presentations of the results of the case studies to be carried out by the students throughout the course. | 5 | D3 |

**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 attend the second call exam when the first call final exam grade is less than 5 points out of 10.

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

* the 2nd call call

* 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.

## Sources of information

### Basic Bibliography

Gómez Tierno M.A., Pérez Cortés M., Puentes Márquez C, **Mecánica del vuelo**, 2, Ibergarceta Publicaciones, 2012

### Complementary Bibliography

Bong Wie, **Space Vehicle Dynamics and Control**, 2, American Institute of Aeronautics and Astronautics, 2008

Bernard Etkin, Lloyd Duff Reid, **Dynamics of flight. Stability and control**, 3, John Wiley & Sons, 1996

## Recommendations

### Subjects that are recommended to be taken simultaneously

Avionics/O07M197V01205

### 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 Enxeñería Aeronáutica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 6 | Mandatory | 1st | 2nd |
| Teaching language | #EnglishFriendly<br>Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | Gómez San Juan, Alejandro Manuel | | | |
| Lecturers | Gómez San Juan, Alejandro Manuel | | | |
| E-mail | alejandromanuel.gomez@uvigo.es | | | |
| Web | http://muea.webs.uvigo.es | | | |
| 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.<br>English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| B3 | Adequate knowledge of metallic and composite materials used in aerospace vehicle manufacturing |
| B5 | Knowledge and skills for the structural analysis and design of aircraft and spacecraft, including the application of advanced structural design and calculation programs |
| D1 | Ability to design, build, inspect, certify and maintain all types of aircraft and spacecraft |

| 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. | D1 |
| GO6. Suitable knowledge of the metallic materials and compound materials used in the manufacture of aerospace vehicles. | B3 |
| GO8. Knowledges and capacities for the analysis and structural design of the aircraft and space vehicles, including the application of programs<br>of calculation and design advanced of structures. | B5 |

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

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Lecturing | 28 | 29 | 57 |

| | | | |
|---|---|---|---|
| Practices through ICT | 15.5 | 0 | 15.5 |
| Case studies | 1 | 73 | 74 |
| Objective questions exam | 2.5 | 0 | 2.5 |
| Case studies | 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 |
| 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 | |
|---|---|
| **Methodologies** | **Description** |
| 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 |

| Assessment | | | | |
|---|---|---|---|---|
| | 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 | B3 B5 | D1 |
| Case studies | Throughout the course, 4 small case studies will be presented that will constitute the different parts of a larger project, each being 15% of the total grade. The objective will be to structurally design the wing of an aircraft, for which<br>1 - The loads will be derived from the flight envelope<br>2 - The wing will be designed based on analytical principles<br>3 - A finite element model of the wing will be created<br>4 - Additionally, some dynamic loads will be applied | 60 | B3 B5 | D1 |

**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.

## Sources of information

**Basic Bibliography**

**Complementary Bibliography**


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

D. J. Peery, **Aircraft Structures**, Dover Publications, 2011

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

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

J. Wijker, **Spacecraft Structures**, Springer, 2008

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


## Recommendations

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

Flight dynamic/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 Enxeñería Aeronáutica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 6 | Mandatory | 1st | 2nd |
| Teaching language | #EnglishFriendly Spanish | | | |
| Department | | | | |
| Coordinator | Gómez San Juan, Alejandro Manuel | | | |
| Lecturers | Gómez San Juan, Alejandro Manuel | | | |
| E-mail | alejandromanuel.gomez@uvigo.es | | | |
| Web | http://muea.webs.uvigo.es | | | |
| General description | In this subject the main aim is to develop the capacity to design and calculate performances of jet engines and their components.<br>English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| B9 | Adequate knowledge of aerojets, gas turbines, rocket engines and turbomachines. |
| B10 | Adequate knowledge of the different subsystems of aerospace vehicle propulsion plants. |
| C2 | Ability to design, build and select the most suitable power plant for an aerospace vehicle, including self-derived power plants |
| C3 | Ability to design, execute and analyze propulsion system tests, and to carry out the complete propulsion system certification process. |
| D6 | Ability to undertake the mechanical design of different components of a propulsion system, as well as the propulsion system as a whole. |

| 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. | C2 |
| GO16. Know adapted of jet engines, turbines of gas, engines rocket and turbomáchinery. | B9 |
| GO17. Capacity to tackle the mechanical design of distinct components of a propulsive system, as well as of the system propulsive in his group. | D6 |
| GO18. Capacity to design, execute and analyse the essays of propulsive systems , and to carry out the complete process of certification of the same.. | C3 |
| GO19. Suitable knowledge of the distinct subsystems of the propulsive plants of aerospace vehicles. | B10 |

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

| | |
|---|---|
| Technicians of simulation | -Types of models of jet engines<br>-Decomposition of systems<br>-Levels of fidelity |
| Introduction to space propulsion systems | -Introduction to autonomous propulsion systems<br>-Chemical rocket engines<br>-Solid propellant rocket engines<br>-Liquid propellant rocket engines |

## Planning

| | 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.

## Methodologies

| | Description |
|---|---|
| Lecturing | Exhibition by part of the professor of the contents on the matter object of study, theoretical bases and<br>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<br>of procedures of transformation of the available information and the interpretation of the results. It is used to employ as<br>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 |

## Personalized assistance

| 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 lesons 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 | (*)Dous exames baseados na resolución de problemas e/ou preguntas conceptuais<br>sobre os contidos da materia. O primeiro realizarase en clase e o segundo será en data de exame oficial. Nota<br>mínima de 5.0. Cada exame valerá o 40% da nota final. | 80 | B9<br>B10 | C2<br>C3 | D6 |
| Essay | (*)Traballo que consiste no deseño dun sistema de propulsión cos conceptos apresos na materia e con presentación en clase | 20 | B9<br>B10 | C2<br>C3 | D6 |

## 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.

## Sources of information

### Basic Bibliography

### Complementary Bibliography

J.L Kerrebrock, **Aircraft Engines and Gas Turbines**, 2, MIT Press, 1992
G. Sutton, **Rocket Propulsion Elements**, 9, Wiley, 2016

## 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 | #EnglishFriendly<br>Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | Veiga López, Fernando | | | |
| Lecturers | González Jorge, Higinio<br>Veiga López, Fernando | | | |
| E-mail | fernando.veiga@uvigo.gal | | | |
| Web | http://muea.webs.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.<br><br>English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| B11 | Adequate knowledge of avionics and on-board software, simulation and control techniques used in air navigation. |
| B12 | Adequate knowledge of wave propagation and the problems of links with ground stations. |
| B14 | Adequate knowledge of the different regulations applicable to air navigation and air traffic, as well as the ability to certify air navigation systems. |
| C4 | Ability to define and design air traffic navigation and management systems, to design airspace, maneuvers and aeronautical easements. |
| C5 | Ability to design RADAR systems and air navigation aids. |
| D9 | 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 | Training and Learning Results |
|---|---|
| Ability to define and design air traffic navigation and management systems, to design airspace, maneuvers and aeronautical easements | C4 |
| Adequate knowledge of avionics and on-board software, simulation and control techniques used in air navigation | B11 |
| Adequate knowledge of wave propagation and the problems of links with ground stations | B12 |
| Ability to design RADAR systems and air navigation aids | C5 |
| Adequate knowledge of the different regulations applicable to air navigation and air traffic, as well as the ability to certify air navigation systems | B14 |
| Competence to plan, design, manage and certify the procedures, infrastructures and systems that support aerospace activities, including air navigation systems | D9 |

| Contents | |
|---|---|
| Topic | |
| 1. Introduction to Navigation. Aeronautical cartography. Reference system WGS84 linked to Earth. | - Introduction, motivation, course and evaluation rules, etc.<br>- Review of reference systems applied to aeronautics.<br>- Review of aeronautical cartography. |
| 2. Positioning by situation surfaces based on radio beacons. VOR, ILS, DME systems. | - Review of navigation systems based on ground radio aids. |
| 3. Satellite positioning. GPS, GLONASS, GALILEO systems. ADSB system. | - Review of navigation systems based on satellite radio aids. |
| 4. Inertial measurement systems. | - Operational flight (Random Navigation, PBN).<br>- Guidance, navigation and control: positioning and inertial navigation. |
| 5. Algoritmos de estimación de la posición. Filtro de Kalman. | - Estimation algorithms. Filter of n-measures and alpha-beta (linear).<br>- Kalman filter. |

| | |
|---|---|
| 6. Airspace organization and design. Flow and separation management. | - Introduction to common optimization methods.<br>- Air traffic flow management (ATFM - route optimization)<br>- Laboratory: methods for optimizing air traffic.<br>- Collision and evasion maneuvers.<br>- Laboratory: Collision and evasion maneuvers. |
| 7. CNS/ATM systems. Regulations, definition of operational requirements, operation and maintenance. | - Review of CNS/ATM concepts.<br>- ATM system performance.<br>- Introduction to SESAR.<br>- Laboratory: Flight plan.<br>- Laboratory: Flight simulator.<br>- Air navigation procedures (instrumental approach and takeoff). |

**Planning**

| | 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 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. |

**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 (total - 4 reports, 5% each) | 20 | B11<br>B12<br>B14 | C4<br>C5 | D9 |
| Mentored work | Group project | 25 | B11<br>B12<br>B14 | C4<br>C5 | D9 |
| Objective questions exam | Partial exam I | 27.5 | B11<br>B12<br>B14 | C4<br>C5 | D9 |
| Objective questions exam | Partial exam II | 27.5 | B11<br>B12<br>B14 | C4<br>C5 | D9 |

**Other comments on the Evaluation**

The student will have the right to go for global or continuous evaluation according to the procedure and deadlines established by the center for each call.

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**Continuous assessment:**

When choosing this option, the students must deliver the indicated items, in a timely manner, by the teaching staff of the subject to pass it at the first opportunity, with the percentage of each deliverable being the one indicated in the previous table. The average grade must be higher or equal than 5 to pass the subject.

The laboratory practices will be evaluated by the teaching staff via a reduced report.

Regarding the evaluation of the mentored work, a detailed report will be delivered per group of the entire process and the results obtained by the students and each group will give an oral presentation of the work carried out.

Midterm exams will be carried out in person during school hours in written format, with short answer questions and small problems related to the concepts of the part of the subject evaluated.

In each of the items presented, at least a grade of 4/10 will be required to pass the subject through continuous evaluation at the first opportunity. Furthermore, the average grade of the two midterm exams must be higher than 4.5/10.

If this first opportunity is not passed, the consecutive ones (second opportunity or end of degree) will consist of a global exam of the two indicated parts that will correspond to 100% of the subject, will last 4 hours (2 hours per part), and will be carried out on the official exam dates. It will be necessary to achieve a minimum grade of 5/10 in all parts of the exam to pass the subject. Grades for each part will not be kept between different calls.

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**Global evaluation:**

If global evaluation is selected, the official exam dates in all calls (first opportunity, second opportunity or end of degree) will be used for the student to take a global exam of the subject, divided into two parts as indicated in the continuous evaluation. The qualification for this exam will correspond to a 100% of the grade. It will be necessary to achieve a minimum grade of 5 in all parts of the exam to complete and pass the subject. Grades for each part will not be kept between different calls.

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Calendar of evaluation tests officially approved by the *Xunta de Centro* of the EEAE is published on the website:

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

## Sources of information

### Basic Bibliography

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

### Complementary Bibliography

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

## Recommendations

### Subjects that are recommended to be taken simultaneously

Avionics/O07M197V01205

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Avionics** | | | | |
| Subject | Avionics | | | |
| Code | O07M197V01205 | | | |
| Study programme | (*)Máster Universitario en Enxeñería Aeronáutica | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 6 | Mandatory | 1st | 2nd |
| Teaching language | #EnglishFriendly<br>Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | Veiga López, Fernando | | | |
| Lecturers | Veiga López, Fernando | | | |
| E-mail | fernando.veiga@uvigo.gal | | | |
| Web | http://muea.webs.uvigo.es | | | |
| General description | This subject aims to teach students the main electronic systems present in an aircraft. Mainly, the communication, control, fuel and navigation systems among others.<br><br>English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English. | | | |

| Training and Learning Results | |
|---|---|
| Code | |
| B11 | Adequate knowledge of avionics and on-board software, simulation and control techniques used in air navigation. |
| B12 | Adequate knowledge of wave propagation and the problems of links with ground stations. |
| B13 | Adequate knowledge of aeronautical information technologies and communications. |
| C5 | Ability to design RADAR systems and air navigation aids. |

| 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 | B11 |
| Adequate knowledge of wave propagation and the problems of links with ground stations | B12 |
| Ability to design RADAR systems and air navigation aids | C5 |
| Adequate knowledge of aeronautical information technologies and communications | B13 |

| Contents | |
|---|---|
| Topic | |
| 1. Introduction and specific problems in on-board equipment. | - Introduction, motivation, clarification of evaluation standards. |
| 2. Noise and interference. EM compatibility. Optical and optoelectronic solutions. | - Basic notions of electromagnetic waves and problems derived from wave propagation.<br>- Noise and interference.<br>- Communication systems and MS regulations.<br>- Signals and post-processing laboratory: Introduction to signal processing, signal acquisition and post-processing. |
| 3. Power supply systems. Requirements and structures. | - Electrical system of an aircraft. |
| 4. Sensors, actuators and other input and output devices. | - Aircraft-pilot interface.<br>- Onboard navigation systems.<br>- Inertial sensors - attitude derivation.<br>- Other aircraft systems (fuel, alert, etc.).<br>- UAV avionics. |
| 5. Electronic signal collection and delivery and preprocessing. | - Air data acquisition systems.<br>- External data acquisition laboratory (Pitot + barometric altimeter). |
| 6. Baseband signal transmission. ARINC and MIL buses. | - Description of the most used buses in avionics.<br>- Integration of avionics subsystems. |

| | |
|---|---|
| 7. Information processing and on-board software. Simulation and Control Techniques. | - Necessary concepts of aerodynamics, stability, control and response of the aircraft.<br>- Control laboratory: closed control loop with Arduino (PID).<br>- PCUs and stability increase systems.<br>- Fly by wire.<br>- Autopilot.<br>- Flight management systems (FMS). |

| Planning | | | |
|---|---|---|---|
| | 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 (total - 3 reports, 5% each) | 15 | B11<br>B12<br>B13 | C5 |
| Mentored work | Team project (aircraft control system) | 30 | B11<br>B12<br>B13 | C5 |
| Objective questions exam | Partial exam I | 25 | B11<br>B12<br>B13 | C5 |
| Objective questions exam | Partial examn II | 30 | B11<br>B12<br>B13 | C5 |

**Other comments on the Evaluation**

The student will have the right to go for global or continuous evaluation according to the procedure and deadlines established by the center for each call.

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**Continuous assessment:**

When choosing this option, the students must deliver the indicated items, in a timely manner, by the teaching staff of the subject to pass it at the first opportunity, with the percentage of each deliverable being the one indicated in the previous table. The average grade must be higher or equal than 5 to pass the subject.

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**Global evaluation:**

If global evaluation is selected, the official exam dates in all calls (first opportunity, second opportunity or end of degree) will be used for the student to take a global exam of the subject, divided into two parts as indicated in the continuous evaluation. The qualification for this exam will correspond to a 100% of the grade. It will be necessary to achieve a minimum grade of 5 in all parts of the exam to complete and pass the subject. Grades for each part will not be kept between different calls.

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Calendar of evaluation tests officially approved by the *Xunta de Centro* of the EEAE is published on the website: http://aero.uvigo.es/es/docencia/examenes/

## Sources of information

### Basic Bibliography

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

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

R.P.G. Collinson, **Introduction to Avionics Systems**, 4, Elsevier, 2023

### Complementary Bibliography

## Recommendations

### Subjects that are recommended to be taken simultaneously

Advanced air navigation systems/O07M197V01204