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19902 - BFAE - Broadening of Fundamentals in Aerospace Science and Technology

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering

Teaching unit: 748 - FIS - Department of Physics

Academic year: 2018

Degree: MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2015). (Teaching unit Compulsory)
MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2009). (Teaching unit Compulsory)
DOCTORAL DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2007). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: Defined in the course webpage at the EETAC website.

Others: Defined in the course webpage at the EETAC website.

Opening hours

Timetable: to be arranged via email

Prior skills

Mathematics, Physics, Mechanics, Fluid Mechanics, Thermodynamics, Propulsion, programing, MATLAB, Octave and/or Maple.
Pre-requisites: knowledge of English language and technical vocabulary in English; having completed an undergraduate degree on Physics or Aeronautics Engineering, Aerospace Engineering, Telecomm. Engineering, Industrial Engineering or Electronics Engineering; having coursed preferentially: Advanced Mathematics, Mechanics, Fluid Mechanics, Thermodynamics, Informatics 2 and Aerodynamics and Flight Mechanics. It is very convenient that students have a personal computer (ideally a laptop) with internet connection.

Degree competences to which the subject contributes

Basic:

CB6. (ENG) CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación.
CB7. (ENG) CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.
CB9. (ENG) CB9 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades.
CB10. (ENG) CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Specific:

CE4 MAST. (ENG) CE4: Aplicar el método científico para el estudio de la fenomenología particular del ambiente aeroespacial.

Generical:

CG1 MAST. (ENG) CG1: Identificar y conocer las principales actividades de I+D+i en el campo aeroespacial que se llevan a cabo actualmente a nivel internacional en el ámbito académico, la industria y las mayores agencias espaciales.

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CG2 MAST. (ENG) CG2: Identificar y aplicar los análisis teóricos, experimentales y numéricos fundamentales de uso actual en ingeniería aeroespacial.
CG4 MAST. (ENG) CG4: Participar en un proyecto de I+D+i del ámbito aeroespacial aportando una visión y conocimientos novedosos asociados con las técnicas de uso más puntero en el campo.

Transversal:

CT1b. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results among socio-economic agents involved in research, development and innovation processes.
CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Teaching methodology

METODOLOGÍAS DOCENTES (MD):

• MD1: Clase magistral: Presentación de un tema estructurado lógicamente con la finalidad de facilitar información organizada siguiendo unos criterios adecuados con un objetivo determinado. Esta metodología se centra fundamentalmente en la exposición oral por parte del profesorado de los contenidos sobre la materia objeto de estudio.

• MD2: Clase expositiva participativa: Asumiendo las características del método expositivo, la clase expositiva participativa incorpora elementos de participación e intervención del estudiante, mediante actividades de corta duración en el aula. Como son las preguntas directas, las exposiciones del estudiante sobre temas determinados, o la resolución de problemas vinculados con el planteamiento teórico expuesto. También los debates y las presentaciones hechas por los estudiantes.

• MD5: Trabajo autónomo: Situaciones en que se pide al estudiante que desarrolle las soluciones adecuadas o correctas mediante la ejercitación de rutinas, la aplicación de fórmulas o algoritmos, la aplicación de procedimientos de transformación de la información disponible y la interpretación de los resultados. Esta modalidad da soporte a todas las demás, es decir, el estudiante va a dedicar una gran parte de su tiempo al trabajo personal para afianzar y completar la información recogida en las clases expositivas y participativas y para completar los problemas, cálculos, informes, etc. que resulten de su actividad en las prácticas de laboratorio y las sesiones de problemas y proyectos con soporte del profesor.

• MD6: Trabajo cooperativo: Enfoque interactivo de la organización del trabajo en el aula y fuera de ella, en el cual el estudiante es responsable del propio aprendizaje y del aprendizaje de los compañeros en una situación de corresponsabilidad para conseguir objetivos comunes.

• MD7: Tutoría: Seguimiento del alumno con la finalidad de abrir un espacio de comunicación, conversación y orientación, donde los alumnos tengan la posibilidad de revisar y discutir junto con su tutor temas que sean de su interés, inquietud, preocupación, así´ como también para mejorar el rendimiento académico, desarrollar hábitos de estudio, reflexión y convivencia social.

Learning objectives of the subject

Upon finalization of the subject BFAE, the students should be able of identifying, relating and defining básic and advanced concepts, and should be able of making advanced simulations and calculations with the corresponding mathematical models in the following topics:

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1. Aerodynamics, flight principles and advanced applications (aerodynamics in supersonic and hypersonic regimes, aeroelasticity, wind energy, blended wing /all-wing aircraft, etc.)
2. Advanced prediction and guidance of aircraft trajectories
3. Advanced projects on Air Traffic Management (most recent progresses in projects like SESAR, NextGen, etc.)
4. Advanced propulsion systems
5. Space reentry systems
6. Technical visits (airport, control center, etc.)

Similarly, we would like to remark that the contents of this subject are advanced respect to those of the undergraduate degrees.

Results of the learning process:

• General and solid vision about the fundamentals of the techniques in aerospace engineering
• Knowledge of the most recent technologies in the aerospace sector through the analysis and study of the most recent scientific works.

Study load

Total learning time: 125h	Hours large group:	45h	36.00%
	Hours medium group:	0h	0.00%
	Hours small group:	0h	0.00%
	Guided activities:	0h	0.00%
	Self study:	80h	64.00%

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Content

Aerodynamics, flight principles and advanced applications

Learning time: 22h 50m

Theory classes: 8h
Self study : 14h 50m

Description:
Introduction
Concepts of aerodynamics:
- Equations of Navier-Stokes
- Circulation
- Kelvin Teorem
- Potencial flow
- Equation of Euler, Euler-Bernoulli and Bernoulli
- Venturi Effect
- Teorem of Kutta-Yukovsky
- Hypothesis de Kutta
- Aerodynamics in supersonic and hypersonic regimes

Concepts of flight principles

Related activities:
Guided activities:
- AD1 (A10, EV3): Resolution of exercises and problems as homework by the students.
- AD2 (A03): Proposal of exercises, problems and theoretical analyses in the classroom. Collective discussion about the suitable methods of resolution in each case.

Rated Activities:
- EV1: final exam
- EV3: Resolution of exercices about aircraft performances

Specific objectives:
Introduction
Concepts of Aerodynamics:
- Equations of Navier-Stokes
- Circulation
- Kelvin Teorem
- Potencial flow
- Equation of Euler, Euler-Bernoulli and Bernoulli
- Venturi Effect
- Teorem of Kutta-Yukovsky
- Hypothesis de Kutta

Basic concepts of flight principles

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Aircraft stability and control	Learning time: 9h 25m Theory classes: 3h Self study : 6h 25m

Description:
Introduction
Concepts of stability and control
Tail and types of tails, horizontal tail plane and and vertical tail plane
Primary and secondary control surfaces

Related activities:
Guided activities:
- AD1 (A10, EV3): Resolution of exercises and problems as homework by the students.
- AD2 (A03): Proposal of exercises, problems and theoretical analyses in the classroom. Collective discussion about the suitable methods of resolution in each case.

Rated Activities:
- EF: final exam
- EV3: Resolution of exercises about aircraft stability and control

Specific objectives:
Introduction
Concepts of stability and control
Tail and types of tails, horizontal tail plane and and vertical tail plane
Primary and secondary control surfaces

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Aircraft performances	Learning time: 15h 06m Theory classes: 5h Self study : 10h 06m

Description:
Introduction
Concepts of aircraft performances
Performances of aircraft propelled by propeller and piston engine:
Maximum range and maximum endurance
Performances of aircraft propelled by pure turbojet engine:
Maximum range and maximum endurance

Related activities:
Guided activities:
- AD1 (A10, EV3): Resolution of exercises and problems as homework by the students.
- AD2 (A03): Proposal of exercises, problems and theoretical analyses in the classroom. Collective discussion about the suitable methods of resolution in each case.

Rated Activities:
- EV1: final exam
- EV3: Resolution of exercices about performances

Specific objectives:
Introduction
Concepts of aircraft performances
Performances of aircraft propelled by propeller and piston engine:
Maximum range and maximum endurance
Performances of aircraft propelled by pure turbojet engine:
Maximum range and maximum endurance

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Aircraft propulsion	Learning time: 11h 48m Theory classes: 4h Self study : 7h 48m

Description:
Introduction
Concepts of aircraft propulsion
Types of propulsive systems, advantages and drawbacks, propulsive efficiency
Aircraft propelled with propeller and piston engine
Aircraft propelled with pure turbojet engine
Aircraft propelled with bypass turbojet engine
Aircraft propelled with turboprop engine

Related activities:
Guided activities:
- AD1 (A10, EV3): Resolution of exercises and problems as homework by the students.
- AD2 (A03): Proposal of exercises, problems and theoretical analyses in the classroom. Collective discussion about the suitable methods of resolution in each case.

Rated Activities:
- EV1: final exam
- EV3: Resolution of exercises about aircraft propulsion

Specific objectives:
Introduction
Concepts of aircraft propulsion
Types of propulsive systems, advantages and drawbacks, propulsive efficiency
Aircraft propelled with propeller and piston engine
Aircraft propelled with pure turbojet engine
Aircraft propelled with bypass turbojet engine
Aircraft propelled with turboprop engine

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Navigation and avionics

Learning time: 11h 48m

Theory classes: 4h
Self study : 7h 48m

Description:
Introduction
Concepts of navigation and avionics
Definition of the avionics and especially of the on-board functional elements in relation to the system air navigation:
• navigation systems based on esteemed navigation: Inertial Reference/Navigation Systems (IRS, INS, strapped down), air data system (ADS), ADIRU/ADIRS, etc.
• navigation systems based on external references: NDB-ADF, DME, VOR, ILS, GNSS, etc.
• navigation systems based on RADAR: PSR, SSR, transponder, etc.
Predicción y guiado avanzado de trayectorias de aeronaves

Related activities:
Rated activities:
o EV1: final exam
o EV4a (A02): Rated Activity 4a

Specific objectives:
Introduction
Concepts of navigation and avionics
Definition of the avionics and especially of the on-board functional elements in relation to the system air navigation:
• navigation systems based on esteemed navigation: Inertial Reference/Navigation Systems (IRS, INS, strapped down), air data system (ADS), ADIRU/ADIRS, etc.
• navigation systems based on external references: NDB-ADF, DME, VOR, ILS, GNSS, etc.
• navigation systems based on RADAR: PSR, SSR, transponder, etc.
Predicción y guiado avanzado de trayectorias de aeronaves

Seminars

Learning time: 11h 40m

Theory classes: 4h
Self study : 7h 40m

Description:
Seminars and conferences related with the topics of the subject

Related activities:
A07: Seminars
Rated activities:
o EV1: final exam

Specific objectives:
Seminars and conferences related with the topics of the subject

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Air Traffic Management	Learning time: 11h 48m Theory classes: 4h Self study : 7h 48m

Description:
Introduction
Concepts on Air Traffic Management
Current airspace situation
Future airspace situation
Complexity of air transportation system
Current air transportation system
Limits of current air transportation system
Future of air transportation system:
- Advanced projects on Air Traffic Management (most recent progresses in projects like SESAR, NextGen, etc.)

Model of air transportation system:
- Air Traffic Management (ATM):
  - AirSpace Management (ASM)
  - Air Traffic Flow Management (ATFM)
  - Air Traffic Services (ATS):
    - Services (AS)
    - Flight Information Services (FIS)
    - Air Traffic Control (ATC)

Related activities:
Rated Activities:
- EV1: final exam

Specific objectives:
Introduction
Concepts on Air Traffic Management
Current airspace situation
Future airspace situation
Complexity of air transportation system
Current air transportation system
Limits of current air transportation system
Future of air transportation system:
- Advanced projects on Air Traffic Management (most recent progresses in projects like SESAR, NextGen, etc.)

Model of air transportation system:
- Air Traffic Management (ATM):
  - AirSpace Management (ASM)
  - Air Traffic Flow Management (ATFM)
  - Air Traffic Services (ATS):
    - Services (AS)
    - Flight Information Services (FIS)
    - Air Traffic Control (ATC)

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Advanced propulsion systems	Learning time: 11h 48m Theory classes: 4h Self study : 7h 48m

Description:

Introduction

Concepts of space propulsion, rocketry and rocket engines:

- Supersonic wind tunnel, Laval nozzle (convergent-divergent)
- Velocity of the combustion exhaust gases
- Specific impulse in rocket engines
- Tsiolkovsky Equation
- Staging in rocket launchers
- Delta V or necessary impulse for orbital change maneuvers, etc.

Chemical propulsion systems: Solid, liquid and hybrid propellant rockets

Advanced propulsion systems:

- Electric propulsion systems: grid ion thrusters, etc.
- Nuclear propulsion systems
- Micro-propulsion
- Propellant-less propulsion systems
- Breakthrough technologies

Related activities:

Guided activities:

o AD2 (A03): Proposal of exercises, problems and theoretical analyses in the classroom. Collective discussion about the suitable methods of resolution in each case.

o A05: Discussion in the classroom of problems or articles, realized by the students and moderated by the professor/a (presencial).

Rated Activities:

o EV1: final exam

o EV4b: Rated Activity 4b

Specific objectives:

Introduction

Concepts of space propulsion, rocketry and rocket engines:

- Supersonic wind tunnel, Laval nozzle (convergent-divergent)
- Velocity of the combustion exhaust gases
- Specific impulse in rocket engines
- Tsiolkovsky Equation
- Staging in rocket launchers
- Delta V or necessary impulse for orbital change maneuvers, etc.

Chemical propulsion systems: Solid, liquid and hybrid propellant rockets

Advanced propulsion systems:

- Electric propulsion systems: grid ion thrusters, etc.
- Nuclear propulsion systems
- Micro-propulsion
- Propellant-less propulsion systems
- Breakthrough technologies

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Space re-entry systems

Learning time: 11h 48m

Theory classes: 4h
Self study : 7h 48m

Description:
Introduction
Basic concepts of space re-entry
Aerodynamics in supersonic and hypersonic regime
General equations
Application to ballistic entry
Gliding reentry
Heating in reentry

Related activities:
Guided activities:
- AD1 (A10): Resolution of exercises and problems as homework by the students.
- AD2 (A03): Proposal of exercises, problems and theoretical analyses in the classroom. Collective discussion about the suitable methods of resolution in each case.

Rated Activities:
- EV1: final exam

Specific objectives:
Introduction
Basic concepts of space re-entry
Aerodynamics in supersonic and hypersonic regime
General equations
Application to ballistic entry
Gliding reentry
Heating in reentry

Visit to airport and/or control center

Learning time: 11h 48m

Theory classes: 4h
Self study : 7h 48m

Description:
Visit to Barcelona-El Prat airport

Related activities:
Rated Activities:
- EV1: final exam

Specific objectives:
Visit to Barcelona-El Prat airport

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Qualification system

Defined in the course webpage at the EETAC website.

Regulations for carrying out activities

• For the realization of the activities, it is necessary to bring/use the adequate material previously indicated by the faculty

• The estimated deadlines for the rated activities will be notified to the students at the beginning of the semester. Delays in the delivery will be associated with a corresponding penalty on the mark of the activity

• Plagiarism in rated activities or in the final exam will result in a mark of 0 in that particular rated activity and 0 in the global mark of the subject

• Attending to the various sessions is mandatory. Only absences duly justified will be accepted

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Bibliography

Basic:

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Anderson, John David. Fundamentals of aerodynamics. 3rd. Boston [etc.]: McGraw-Hill, 2001. ISBN 0072373350.

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Fortescue, Peter W.; Stark, John P. W.; Swinerd, Graham. Spacecraft systems engineering [on line]. 3rd. Chichester ; New York: Wiley, 2003 [Consultation: 13/09/2017]. Available on: <http://site.ebrary.com/lib/upcatalunya/docDetail.action?docID=10494538&p00=spacecraft%20systems%20engineering>. ISBN 9780471619512.

Sutton, George P.; Biblarz, Oscar. Rocket propulsion elements [on line]. 7th. New York: John Wiley & Sons, 2001Available on: <http://site.ebrary.com/lib/upcatalunya/detail.action?docID=10501307>. ISBN 0471326429.

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Nelson, Robert C. Flight stability and automatic control. 2nd ed. Boston, Mass.: WCB/McGraw Hill, cop. 1998. ISBN 0070462739.

Mattingly, Jack D. Elements of gas turbine propulsion. New York: McGraw-Hill, cop. 1996. ISBN 0079121969.

Pamadi, Bandu N. Performance, stability, dynamics, and control of airplanes. 2nd ed. Reston: American Institute of Aeronautics and Astronautics, cop. 2004. ISBN 1563475839.

Pallett, E. H. J; Coombs, L. F. E. Aircraft instruments and integrated systems. Harlow [etc.]: Prentice Hall, 1992. ISBN 0582086272.

Humble, Ronald W; Henry, Gary N; Larson, Wiley J. Space propulsion analysis and design. New York: McGraw-Hill, 1995. ISBN 0070313296.

Complementary:

Meseguer Ruiz, José; Sanz Andrés, Angel. Aerodinámica básica. 2a ed., 1a ed. Ibergarceta. Madrid: Garceta, cop. 2011. ISBN 9788492812714.

Others resources:

Power point presentations
Diverse documents in digital or hard copy format
Multimedia material created ad hoc or obtained from the internet
Guidelines for the different activities