Last update: 05-10-2018

220330 - Hypersonic Aerodynamics

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering

Teaching unit: 220 - ETSEIAT - Terrassa School of Industrial and Aeronautical Engineering

Academic year: 2018

Degree: MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)
MASTER'S DEGREE IN SPACE AND AERONAUTICAL ENGINEERING (Syllabus 2016). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: Roberto Flores

Prior skills

The course focuses on very-high-speed flows, therefore a basic understanding of incompressible and compressible aerodynamics is required in order to follow the lectures.

Degree competences to which the subject contributes

Specific:

CEEESPAC1. MUEA/MASE: Sufficient applied knowledge of the planning of space missions (specific competency for the specialisation in Space).

CEEESPAC2. MUEA/MASE: Advanced applied knowledge of orbital dynamics and space vehicle design (specific competency for the specialisation in Space).

Teaching methodology

- Theory lessons: During these lectures the teacher will introduce the theoretical basis, analysis methods and important results. Where appropriate, illustrative examples will be discussed to improve the student's understanding of the subject.

- Practice lessons: During the practice sessions the student will solve, under supervision of the teacher, review exercises in order to gain experience in the application of the analysis methods taught during the theoretical lectures.

- Exams: During the exam sessions the student will demonstrate his understanding of the theory and problem solving skills. There will be an exam for each of the course modules.

- Self-study: While the teacher will present a short overview of the subjects in the classroom, it remains the duty of the student to gain a more in-deep understanding by going over the recommended references. This is fundamental in order to acquire the necessary abilities of critical thinking and autonomous problem-solving.

Learning objectives of the subject

This course serves as an introduction to the field of very high speed aerodynamics. Starting with a review of the foundations of compressible fluid dynamics, the students will be presented with a qualitative overview of the phenomena typical of hypersonic flows. Next, some analysis techniques suitable for the high speed regime will be introduced.

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Study load

Total learning time: 125h	Hours large group:	30h	24.00%
	Hours small group:	15h	12.00%
	Self study:	80h	64.00%

Content

Module 1: Review of compressible fluid dynamics	Learning time: 50h Theory classes: 12h Practical classes: 6h Self study : 32h

Description:
1. Review of the basic equations of fluid dynamics
2. Dimensionless parameters
3. Simple solutions of the Euler equations:
- Shockwaves
- Expansion fans
- Contact discontinuities

Related activities:
Theory lessons
Practice lessons
Module 1 exam

Module 2: Characteristics of hypersonic flows	Learning time: 34h Theory classes: 9h Practical classes: 5h Self study : 20h

Description:
4. Hypersonic phenomena:
- Temperature dependent fluid properties
- Thin shock layer
- Entropy layer
- Reacting flows
- Rarefied flows

Characteristics of hypersonic vehicles

Related activities:
Theory lessons
Practice lessons
Module 2 exam

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Module 3: Numerical solutions of the flow equations.	Learning time: 41h Theory classes: 9h Practical classes: 4h Self study : 28h

Description:
5. Newtonian solutions of hypersonic flows
6. Numerical solution of the Euler equations:
- Finite volume approximations
- Stabilization of convection-dominated equations
- Boundary conditions

Related activities:
Theory lessons
Practice lessons
Module 3 exam

Qualification system

In principle, the final course grade is a weighted average of the grades awarded in the exams of the 3 course modules. However, the final exam includes all the contents of the course, so it serves also as a retake for students whose average grade is not satisfactory. The final course grade shall be the maximum of the weighted average and the final exam result:

Final grade = MAX(Exam_3, Average_grade)
where
Average_grade 0,30·Exam_1 + 0,35·Exam_2 + 0,35·Exam_3

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.
If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

Bibliography

Basic:

Anderson, J.D. Hypersonic and high-temperature gas dynamics. 2nd ed. Reston: American Institute of Aeronautics and Astronautics, cop. 2006. ISBN 9781563477805.

Complementary:

Hirsch, Charles. Numerical computation of internal and external flows: fundamentals of computational fluid dynamics [on line]. 2nd ed. Amsterdam: Butterworth-Heinemann, 2007 [Consultation: 29/06/2017]. Available on: <http://www.sciencedirect.com/science/book/9780750665940>. ISBN 9780750665940.

Anderson, J.D. Modern compressible flow: with historical perspective. 3rd ed. Boston: McGraw-Hill, 2003. ISBN 9780071241366.