Course guide
220330 - 220330 - Hypersonic Aerodynamics

Last modified: 19/04/2023

Unit in charge: Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 220 - ETSEIAT - Terrassa School of Industrial and Aeronautical Engineering.

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

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Roberto Flores

Others:

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.

STUDY LOAD

Type	Hours	Percentage
Self study	80,0	64.00
Hours small group	15,0	12.00
Hours large group	30,0	24.00

Total learning time: 125 h

CONTENTS

Module 1: Review of compressible fluid dynamics

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

Full-or-part-time: 50h
Theory classes: 12h
Practical classes: 6h
Self study : 32h

Module 2: Characteristics of hypersonic flows

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

Full-or-part-time: 34h
Theory classes: 9h
Practical classes: 5h
Self study : 20h

Module 3: Numerical solutions of the flow equations.

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

Full-or-part-time: 41h
Theory classes: 9h
Practical classes: 4h
Self study : 28h

GRADING 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:
- Anderson, J.D. Modern compressible flow: with historical perspective. 3rd ed. Boston: McGraw-Hill, 2003. ISBN 9780071241366.
- Hirsch, Charles. Numerical computation of internal and external flows: fundamentals of computational fluid dynamics [on line]. 2nd ed. Amsterdam: Butterworth-Heinemann, 2007 [Consultation: 03/05/2022]. Available on: https://www-sciencedirect-com.recursos.biblioteca.upc.edu/book/9780750665940/numerical-computation-of-internal-and-external-flows. ISBN 9780750665940.