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-depth 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

<table>
<thead>
<tr>
<th>Description</th>
<th>Time (h)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total learning time</strong></td>
<td>125</td>
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<tr>
<td>Hours large group:</td>
<td>30</td>
<td>24.00%</td>
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<tr>
<td>Hours small group:</td>
<td>15</td>
<td>12.00%</td>
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<tr>
<td>Self study:</td>
<td>80</td>
<td>64.00%</td>
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</table>
## Content

<table>
<thead>
<tr>
<th>Module 1: Review of compressible fluid dynamics</th>
<th>Learning time: 50h</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 12h</td>
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<tr>
<td>1. Review of the basic equations of fluid dynamics</td>
<td>Practical classes: 6h</td>
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<td>2. Dimensionless parameters</td>
<td>Self study: 32h</td>
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<td>3. Simple solutions of the Euler equations:</td>
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<tr>
<td>- Shockwaves</td>
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<td>- Expansion fans</td>
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<td>- Contact discontinuities</td>
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<tr>
<td><strong>Related activities:</strong></td>
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<tr>
<td>Theory lessons</td>
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<tr>
<td>Practice lessons</td>
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<tr>
<td>Module 1 exam</td>
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<tr>
<th>Module 2: Characteristics of hypersonic flows</th>
<th>Learning time: 34h</th>
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<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 9h</td>
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<td>4. Hypersonic phenomena:</td>
<td>Practical classes: 5h</td>
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<td>- Temperature dependent fluid properties</td>
<td>Self study: 20h</td>
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<td>- Thin shock layer</td>
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<td>- Entropy layer</td>
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<td>- Reacting flows</td>
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<td>- Rarefied flows</td>
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<tr>
<td>Characteristics of hypersonic vehicles</td>
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<tr>
<td><strong>Related activities:</strong></td>
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<tr>
<td>Theory lessons</td>
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<tr>
<td>Practice lessons</td>
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<tr>
<td>Module 2 exam</td>
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</table>
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:

\[
\text{Final grade} = \text{MAX(Exam}_3, \text{Average grade)}
\]

\[
\text{Average grade} = 0,30 \cdot \text{Exam}_1 + 0,35 \cdot \text{Exam}_2 + 0,35 \cdot \text{Exam}_3
\]

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.

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### Bibliography

**Basic:**


**Complementary:**
