220340 - Extension of Rocket Engines

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: Manel Soria Guerrero
Oriol Lizandra Dalmases

Prior skills
Previous concepts include knowledge of propulsion systems for aircraft and spacecraft, given in any bachelor's degree in aerospace engineering and reviewed in previous subjects of this Master's degree, as well as familiarity with the use of computing tools for engineering.

Degree competences to which the subject contributes
Specific:
CEEPROP2. MUEA/MASE: Advanced applied knowledge of the design, manufacture and maintenance of propulsion systems (specific competency for the specialisation in Propulsion).
CEEAEROP1. MUEA/MASE: The ability to analyse airport operations, planning and air transport (specific competency for the specialisation in Airports).

Teaching methodology
Classroom lectures combined with assignments to be solved during the class with the help of the professor

Learning objectives of the subject
Understand advanced concepts of rocket engines design such as cooling, propellant feeding methods, instabilities and nozzle design.
Acquire a hands-on experience on experimental testing of small scale rocket engines with gas, solid and hybrid propellants
Understand the fundamentals of cryogenic propellants

Study load
<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 30h</th>
<th>24.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours small group: 15h</td>
<td>12.00%</td>
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<td>Self study: 80h</td>
<td>64.00%</td>
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## Content

<table>
<thead>
<tr>
<th>Module 1: Nozzle design. Method of characteristics</th>
<th>Learning time: 14h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 3h</td>
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<td>Practical classes: 1h</td>
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<td>Self study: 10h</td>
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**Description:**
Analysis of design of rocket nozzles using the method of characteristics.

<table>
<thead>
<tr>
<th>Module 2: Nozzle cooling. Liquid cooling, ablation cooling, thermal inertia</th>
<th>Learning time: 15h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 3h</td>
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<tr>
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<td>Practical classes: 2h</td>
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<tr>
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<td>Self study: 10h</td>
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**Description:**
Liquid cooling
Ablation cooling
Thermal inertia cooling
Development of simulation software.

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<tr>
<th>Module 3: Cryogenic propellants</th>
<th>Learning time: 16h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 4h</td>
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<tr>
<td></td>
<td>Practical classes: 2h</td>
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<td>Self study: 10h</td>
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**Description:**
Evaluation of propellants properties.
Cryogenic cycles.
Main safety issues.

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<thead>
<tr>
<th>Module 4: Propellant feeding methods. Pressure feed, turbopump based cycles. Steady-state and transient behaviour</th>
<th>Learning time: 16h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 4h</td>
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<tr>
<td></td>
<td>Practical classes: 2h</td>
</tr>
<tr>
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<td>Self study: 10h</td>
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**Description:**
Pressure feed systems
Turbopump based cycles.
Steady-state and transient behaviour
### Module 5: Combustion instabilities

**Learning time:** 16h  
- Theory classes: 4h  
- Practical classes: 2h  
- Self study: 10h  

**Description:**  
Fundamental aspects  
Modelling of instabilities

### Module 6: Modelling of solid propellant rockets

**Learning time:** 16h  
- Theory classes: 4h  
- Practical classes: 2h  
- Self study: 10h  

**Description:**  
Modelling pressure transients in combustion chamber.  
Computational geometry tools for the prediction of burning profiles.  
Two dimensional and three dimensional grain profiles.

### Module 7: Rocket trajectories

**Learning time:** 16h  
- Theory classes: 4h  
- Practical classes: 2h  
- Self study: 10h  

**Description:**  
Trajectory modelling  
Gravity turn  
Coupling between engine and trajectory analysis.

### Module 8: Rocket testing and instrumentation

**Learning time:** 16h  
- Theory classes: 4h  
- Practical classes: 2h  
- Self study: 10h  

**Description:**  
Load-cells  
Telemetry  
Ignition systems  
Measuring solid fuel burning rates.
Qualification system

Assignments 30%
Project 40%
Exam 30%

Students with a grade below 5.0 in the assignments and / or the project, will be able to do an additional exam in order to compensate for the poor results. The new grade will replace the original only if it is higher. The maximum grade that can be obtained with this additional exam is 5.0.

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:


