Course guide
220334 - 220334 - Space Propulsion

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: 2022   ECTS Credits: 5.0   Languages: English

LECTURER

Coordinating lecturer: Lizandra Dalmases, Josep Oriol
Others: Mudarra López, Miguel
Soria Guerrero, Manel

PRIOR SKILLS

Previous concepts include a great variety of subjects and disciplines given in any bachelor’s degree in aerospace engineering, in especial, thermal rockets, but also: compressible fluid mechanics, elements of orbital mechanics, electromagnetism and statistical mechanics.

Taking these basic concepts, the course on Space Propulsion develops most of the scientific formulations necessary for the correct understanding of the thrusters, including some concepts of theory of plasmas. Thus, this field doesn’t constitute a previous requirement.

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

Classroom theory sessions to teach concepts and developments, combined with applied exercises in class, or teamwork assignments.

LEARNING OBJECTIVES OF THE SUBJECT

This subject aims the student to be familiar with the different types of thrusters used in spacecraft, especially, satellites orbiting the Earth. Once coursed and passed the student should:
1. Be aware of the needs for, and be able of carrying out, a mission optimization, including the Flight Dynamics with low thrust, the computation of velocity increments for several typical missions, accounting for the limited available power of most thrusters, affecting the acceleration attainable by the spacecraft.
2. Know the physics, design and performance of Electrothermal engines (resistojet and arcjet).
3. Have an adequate knowledge on plasma physics, on which the principles of operation of some types of thrusters is based.
4. Have a comprehensive knowledge of thrusters based on plasma physics: Hall Effect thrusters, ion and MPD thrusters.
5. Have notions about the expansion of a plasma plume into the vacuum, and application to the interaction between motor and satellites.
6. Have an adequate knowledge on electrodispersion of conductive fluids, with application to colloidal thrusters and ionic thrusters with ions from liquid origin.
7. Have notions about test facilities and techniques for this type of engines.
**STUDY LOAD**

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>30,0</td>
<td>24.00</td>
</tr>
<tr>
<td>Hours small group</td>
<td>15,0</td>
<td>12.00</td>
</tr>
<tr>
<td>Self study</td>
<td>80,0</td>
<td>64.00</td>
</tr>
</tbody>
</table>

Total learning time: 125 h

**CONTENTS**

**Module 1: Mission Analysis**

**Description:**

**Specific objectives:**
...

**Related activities:**
Exam and/or assignment

**Full-or-part-time:** 15h
- Theory classes: 4h
- Laboratory classes: 2h
- Self study: 9h

**Module 2: Chemical thrusters.**

**Description:**
Module 2: Chemical thrusters.

**Specific objectives:**

**Related activities:**
Exam and/or assignment

**Full-or-part-time:** 14h
- Theory classes: 4h
- Laboratory classes: 1h
- Self study: 9h
Module 3: Electrothermal thrusters

Description:

Specific objectives:
...

Related activities:
Exam and/or assignment.

Full-or-part-time: 14h
Theory classes: 3h
Laboratory classes: 2h
Self study : 9h

Module 4: Introduction to magnetized plasmas

Description:

Specific objectives:
...

Related activities:
Exam and/or assignment

Full-or-part-time: 14h
Theory classes: 4h
Laboratory classes: 1h
Guided activities: 9h

Module 5: Ionic thrusters

Description:

Related activities:
Exam and/or assignment.

Full-or-part-time: 14h
Theory classes: 3h
Laboratory classes: 2h
Self study : 9h
### Module 6: Hall thrusters

**Description:**

**Full-or-part-time:** 14h  
Theory classes: 3h  
Laboratory classes: 2h  
Self study : 9h

### Module 7: Self-induced field MPD thrusters

**Description:**

**Full-or-part-time:** 12h  
Theory classes: 3h  
Laboratory classes: 1h  
Self study : 8h

### Module 8: Plasma plumes. Interaction plume-spacecraft.

**Description:**
Basic physics of a plasma plume into the vacuum. Far limit. Charge exchange due to collisions, effects on the ions distribution. Estimation. Other effects.

**Full-or-part-time:** 8h  
Theory classes: 2h  
Laboratory classes: 1h  
Self study : 5h

### Module 9: Surface Electrostatics. Colloidal thrusters.

**Description:**

**Full-or-part-time:** 14h  
Theory classes: 3h  
Laboratory classes: 2h  
Self study : 9h
Module 10: Test stands and techniques.

Description:

Full-or-part-time: 6h
Theory classes: 1h
Laboratory classes: 1h
Self study: 4h

GRADING SYSTEM

The global grade is computed with the formula:

\[ N_{\text{glob}} = 0.8 \times (N_1 + N_2) + 0.2 \times N_{\text{ass}} \]

\( N_1 \) and \( N_2 \) are, respectively, the grades of the first and final exam. \( N_{\text{ass}} \) is the grade of the team assignment.

All those students aiming at improving the grade \( N_1 \) achieved in the first exam or that were not able to attend it on the indicated date, will have another opportunity the same day of the final exam or another close date.

The new grade will replace the old one in any case, except in the following cases:

- If the old grade is higher or equal than 5, and the new grade is lower than 5, the grade for \( N_1 \) will be 5.
- If the old grade is lower than 5 but higher or equal than 4, and the new grade is lower than 4, the grade for \( N_1 \) will be 4.

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

EXAMINATION RULES.

The conditions and regulations to carry out will the exams and assignments and will be announced in class and/or through Atenea (digital campus).

BIBLIOGRAPHY

Basic:

RESOURCES

Hyperlink:
- MITOpenCourseWare. MIT Open Courseware, Notes on Space Propulsion, by Manuel Martinez-Sánchez