220057 - Space Engineering

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: BACHELOR'S DEGREE IN AEROSPACE TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Compulsory)
ECTS credits: 6 Teaching languages: Spanish, English

Teaching staff
Coordinator: Enrique García-Berro

Opening hours
Timetable: To be agreed

Prior skills
The student must have a solid base in algebra, trigonometry, geometry, fundamental physics (point dynamics, rigid body dynamics, electromagnetism), heat transfer by conduction and radiation.

Requirements
For the correct understanding of the contents of the course, it is mandatory to have coursed Physics I, II, III, Algebra, Calculus I, Thermodynamics, Electrical Circuits, Mechanics. Besides, it is recommended to have coursed Propulsion and Gas Dynamics and Heat and Mass Transfer

Degree competences to which the subject contributes

Specific:
1. GrETA - An adequate understanding of the following, as applied to engineering: physical phenomena of flight, flight qualities and control, aerodynamic and propulsive forces, performance and stability.

Transversal:
2. SUSTAINABILITY AND SOCIAL COMMITMENT - Level 3. Taking social, economic and environmental factors into account in the application of solutions. Undertaking projects that tie in with human development and sustainability.

Teaching methodology
The teaching method consists in:
* classroom lectures
* Classroom sessions of practical work (exercises and problems). In the former, the teacher shall introduce and explain concepts, contents, methods and results, also with the support of examples, images and videos. In the practical sessions, the teacher shall guide the students in the application of the theoretical concepts to the solution of problems, and shall do so by stimulating critical reasoning.
220057 - Space Engineering

Learning objectives of the subject

At the end of the course the student shall be able to analyse and design a space system based on simplified models. The aspects on which the course is focussed are the following:

* Space environment
* Orbital dynamics
* Launch and space propulsion
* Satellite subsystems
* Payload

The course aims at preparing the student for understanding, analysing and designing models of each of the above aspects. He/she shall develop and consolidate basic capabilities in the design of a space system.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>32h</th>
<th>21.33%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>14h</td>
<td>9.33%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>14h</td>
<td>9.33%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>
## Content

### Module 1

<table>
<thead>
<tr>
<th><strong>Learning time:</strong> 5h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 2h</td>
</tr>
<tr>
<td>Self study: 3h</td>
</tr>
</tbody>
</table>

**Description:**
Introduction to the course: what is space? Past, present and future of the space activities

**Related activities:**
Ac. 1

**Specific objectives:**
Knowledge of following issues:
* historical, scientific and technological context of the subject of the course,
* phases of the development of the space vehicles
* current state of the conquest and use of space
* future trends in space activities

### Module 2

<table>
<thead>
<tr>
<th><strong>Learning time:</strong> 20h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>Self study: 12h</td>
</tr>
</tbody>
</table>

**Description:**
Space environment:
* Physics of the space environment: Earth's atmosphere (temperature, density and pressure profiles, composition), gravitational field, geomagnetic field, ionosphere, radiation structures, terrestrial magnetosphere and interactions with charged particles of solar and galactic origin, space debris and micrometeoroids.
* Effects of the space environment on satellites: vacuum conditions (outgassing), effects of UV light, charged particles, thermal radiation, absorption of particle radiation (dose and single events), impacts of micrometeoroids and space debris.

**Related activities:**
Ac. 1, 2, 3, 4

**Specific objectives:**
Understanding of the physical environment of a satellite in planetocentric and interplanetary orbit, insight into the unfavourable effects that the space environment has on the components and functions of a space vehicle.
Module 3

**Description:**
Astrodynamics:
* Space and time reference systems (time scales and geocentric, heliocentric and satellite-based reference frames)
* Keplerian orbits and their perturbations (Kepler laws, trajectory equation, energy and angular momentum conservation, orbital elements and relations with position and velocity as functions of time, orbit types, perturbations produced by the Earth's mass distribution, radiation pressure, third body and atmospheric drag)
* Impulsive orbital maneuvers (rocket equation, in-plane and out-of-plane one-impulse maneuvers, Hohmann transfers),
* Interplanetary trajectories (patched conics and gravity assist)

**Related activities:**
Ac. 1, 2, 3, 4

**Specific objectives:**
Good knowledge of basic orbital dynamics and the most common impulsive maneuvers. Knowledge of the patched conics technique for the design of an interplanetary trajectory

---

Module 4

**Description:**
Space transportation: launch dynamics (ascent phases, principles and advantages of staging, launch sites and vehicles used by the several space agencies and private industries, launch windows, allowed launch azimuth intervals), space propulsion (types of engines, performance and use), approaches to a planet (B-plane and orbital parameters), atmospheric entry, descent and landing in different planets and atmospheres.

**Related activities:**
Ac. 1, 2, 3, 4

**Specific objectives:**
Understanding of the dynamics, kinematics and geometry of launch, knowledge of the several types of engines for space propulsion (electrical, chemical, etc.), understanding of the different strategies and way of approaching a planet
### Module 5

**Learning time:** 48h  
- Theory classes: 10h  
- Practical classes: 5h  
- Laboratory classes: 5h  
- Self study: 28h

**Description:**  
Subsystems of a space vehicle: introduction (anatomy of the space vehicle), electrical power subsystem, thermal control, structure and mechanisms, attitude determination and control, communications subsystem, life support subsystem

**Related activities:**  
Ac. 1, 2, 3, 4

**Specific objectives:**  
- Understanding of the physics and technology of the several subsystems that make up a space vehicle.  
- Knowledge of their interactions with the space environment.  
- Capability to evaluate, choose and design the basic elements of the fundamental subsystems of a satellite.

### Module 6

**Learning time:** 12h  
- Theory classes: 2h  
- Practical classes: 1h  
- Laboratory classes: 1h  
- Self study: 8h

**Description:**  
Payload: remote sensing detectors and optical systems with applications (astrophysics, Earth observation, service)

**Related activities:**  
Ac. 1, 2, 3, 4
## Planning of activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Support materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACTIVITY 1 - THEORY LECTURES</strong></td>
<td></td>
<td>Lecture notes</td>
</tr>
<tr>
<td><strong>ACTIVITY 2 - EXERCISE SESSIONS</strong></td>
<td></td>
<td>Lecture notes</td>
</tr>
<tr>
<td><strong>ACTIVITY 3 - TEST EXERCISES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ACTIVITY 4 - PARTIAL EXAM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ACTIVITY 5 - FINAL EXAM</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Hours

<table>
<thead>
<tr>
<th>Activity</th>
<th>Theory classes</th>
<th>Self study</th>
<th>Practical classes</th>
<th>Laboratory classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITY 1</td>
<td>28h</td>
<td>90h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACTIVITY 2</td>
<td>14h</td>
<td></td>
<td></td>
<td>7h</td>
</tr>
<tr>
<td>ACTIVITY 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACTIVITY 4</td>
<td>2h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACTIVITY 5</td>
<td>2h</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Qualification system

The mark of the course is assessed on the basis of these evaluation items:
* Final exam (50%)  
* Test exercises (25%)  
* Deliverables (25%)

Low results can be recovered with an additional written exam. All students can do it. The mark obtained will supersede the previous one. This exam will be done on demand, and it will be conducted upon agreement with the student.

### Regulations for carrying out activities

The test exercises shall be carried out in small groups and in written form.
Bibliography

Basic:


