300206 - MEC - Mechanics

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING - NETWORK ENGINEERING (AGRUPACIÓ DE SIMULTANEITAT) (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)
ECTS credits: 6
Teaching languages: Catalan, Spanish, English

Teaching staff
Coordinator: Definit a la infoweb de l'assignatura.
Others: Definit a la infoweb de l'assignatura.

Opening hours
Information is provided at the beginning of the academic term.

Prior skills
- Developed skills in basics of trigonometry, vector calculus, differential and integral calculus.
- Familiarity with the concepts of physical magnitude, units and unit conversion.
- Familiarity in the use of scientific notation.
- Familiarity with the concepts of force, work, energy, rigid solid and field.

Degree competences to which the subject contributes
Specific:
1. CE 2 AERO. Comprensión y dominio de los conceptos básicos sobre las leyes generales de la mecánica, termodinámica, campos y ondas y electromagnetismo y su aplicación para la resolución de problemas propios de la ingeniería. (CIN/308/2009, BOE 18.2.2009)

Transversal:
2. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.
3. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
300206 - MEC - Mechanics

**Teaching methodology**

Master classes are combined with applied lectures and the use of multimedia material. Master classes will mainly follow the talk-chalk method, so that the teacher may efficiently present the main concepts and physical laws. These will be later applied during homework and exercise sessions. Students' participation will be encouraged during lessons. Specific examples will be chosen according both to their pedagogical value (in order to clarify as much as possible theoretical concepts) and to the specific degree this subject belongs to, in order to motivate students. Besides multimedia tools will be used whenever possible, in order to help visual understanding.

Oriented activities are aimed to facilitate students' participation, and let them develop, either individually or in groups, the work done during master classes. Profit from oriented activities is directly related to autonomous dedication time. Small group discussions will be favoured for the students to share the approach and results of exercises done as homework.

A computing project will be proposed, in order to help the development of transversal activities, and to deepen in the concepts of this subject. A computer code to be written in small groups, and the detailed analysis of results will be expected. Projects and a related test will be evaluated with 20% of the subjects total mark.

**Learning objectives of the subject**

At the end of the term students must be able to:

- Solve basic Mechanical problems using Newton Laws and integration methods (for non-constant forces).
- Use conservation theorems (linear and angular momentum, energy).
- Identify different types of oscillators. Write and solve their equations of motion.
- Know the magnitudes of power, bandwidth, frequency of resonance, relaxation time and quality factor.
- Define the concepts of conservative force and central force. Identify and calculate basic orbital parameters. Define and calculate transfer orbits of different types.
- Define inertial and non-inertial frames of reference. Express and transform magnitudes between different frames and the intervening forces.
- Explain the concepts of tensor of inertia, Euler equations, Euler angles and Euler angle rates, both in classical and aeronautical notation. Explain cases of basic rotational dynamics.
- Be efficient both in oral and written communication in order to justify scientific reasoning with qualitative and quantitative arguments. Critically analyse reasoning, in order to detect and ultimately avoid errors.

**Study load**

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group: 42h</th>
<th>28.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Guided activities: 24h</td>
<td>16.00%</td>
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<tr>
<td></td>
<td>Self study: 84h</td>
<td>56.00%</td>
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</table>
### Content

<table>
<thead>
<tr>
<th><strong>Introduction to Classical Mechanics</strong></th>
<th><strong>Learning time:</strong> 20h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 5h 30m</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 3h</td>
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<tr>
<td></td>
<td>Self study: 12h</td>
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</table>

**Description:**
- Introduction and basic concepts.
- Applications: Newton laws with variable forces.

**Related activities:**
2 sessions in this block. Proposed activities:
- Session 1: discuss and correct exercises (conservation principles, time-dependent forces)
- Session 2: discuss and correct exercises (velocity and position-dependent forces)

<table>
<thead>
<tr>
<th><strong>(ENG) Títol contingut 2: Oscil·lacions</strong></th>
<th><strong>Learning time:</strong> 21h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 7h</td>
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<tr>
<td></td>
<td>Guided activities: 3h</td>
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<td>Self study: 11h</td>
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</table>

**Description:**
- Review Simple Harmonic Oscillations.
- Damped oscillations.
- Driven oscillations. Resonance.

**Related activities:**
3 sessions in this block. Proposed activities:
- Session 3: discuss and correct exercises (simple and damped oscillators; driven oscillators and resonance)
- Session 4: Test
### (ENG) Títol contingut 3: Forces centrals

**Description:**
- Plane kinematics
- 3-dimensional motion. Angular momentum
- Conservative forces and potential energy. Central forces.
- Motion under central forces inversely proportional to the square of the distance. Gravity. Orbital parameters. Kepler’s laws.
- Ellipticcal, parabolic and hyperbolic orbits.
- Transfer orbits. Hohmann orbits.

**Related activities:**
2 sessions in this block. Proposed activities:
- Session 5: discuss and correct exercises (plane kinematics. Central forces)
- Session 6: discuss and correct exercises (orbital parameters and transfer orbits)

<table>
<thead>
<tr>
<th>Learning time: 20h 30m</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 5h 30m</td>
</tr>
<tr>
<td>Guided activities: 3h</td>
</tr>
<tr>
<td>Self study : 12h</td>
</tr>
</tbody>
</table>

### (ENG) Títol contingut 4: Sistemes de Partícules

**Description:**
- Dynamics of systems of particles.
- Linear momentum and energy conservation for systems of particles.
- Centre of mass.
- Variable-mass problems. The rocket equation.

**Related activities:**
1 session in this block. Proposed activities:
- Session 7: discuss and correct exercises (conservation principles, centre of mass, rocket equation)

<table>
<thead>
<tr>
<th>Learning time: 17h 30m</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 5h</td>
</tr>
<tr>
<td>Guided activities: 1h 30m</td>
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<tr>
<td>Self study : 11h</td>
</tr>
</tbody>
</table>
### (ENG) Títol contingut 6: Sistema de coordenades mòbils

**Description:**
- Rotating frames of reference.
- Centrifugal and Coriolis acceleration.

**Related activities:**
- 2 sections in this block. Proposed activities:
  - Session 8: discuss and correct exercises (conservation principles, time-dependent forces)
  - Session 9: discuss and correct exercises (velocity and position-dependent forces)

### Learning time:
- Theory classes: 5h 30m
- Guided activities: 3h
- Self study: 12h

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### (ENG) Sòlid Rígid. Rotació entorn d'un eix fix i en torn a un eix variable.

**Description:**
- Dynamics of rigid solid
- Review rotation about a fixed axis.
- Angular momentum and tensor of inertia of a rigid solid.
- Kinetic energy of a rigid solid.
- Motion of rigid solid in space.
- Euler equations.
- Euler angles. Euler angle rates.

**Related activities:**
- 2 sessions in this block. Proposed activities:
  - Session 10: discuss and correct exercises (review 1-dim rotation. Tensors of inertia.)
  - Session 11: discuss and correct exercises (tensors of inertia and Euler equations. Euler angles and Euler angle rates).
  - Session 12: Test.

### Learning time:
- Theory classes: 9h
- Guided activities: 3h
- Self study: 18h
<table>
<thead>
<tr>
<th><strong>Planning of activities</strong></th>
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</thead>
</table>
| *(ENG) TÍTOL ACTIVITAT 1: INTRODUCCIÓ A L'ASSIGNATURA* | **Hours:** 2h  
Guided activities: 2h  |

**Description:**  
Introduction to Classical Mechanics. Exercises of variable forces.

**Support materials:**  
Online version of exercise collection and solved examples.

**Descriptions of the assignments due and their relation to the assessment:**  
Students will hand in proposed exercises during the session.

**Specific objectives:**  
Introduction to Classical Mechanics course. Consolidate concepts of basic Physics. Understand and solve problems involving variable forces.

| *(ENG) TÍTOL ACTIVITAT 2: FORCES DEPENDENTS DE LA POSICIÓ, EL TEMPS I LA VELOCITAT* | **Hours:** 2h  
Guided activities: 2h  |

**Description:**  
Problems on variable forces will be solved and discussed.

**Support materials:**  
Online version of exercise collection and solved examples.

**Descriptions of the assignments due and their relation to the assessment:**  
Students will hand in proposed exercises.

**Specific objectives:**  
Understand and solve variable forces exercises.

| **VARIABLE FORCES II** | **Hours:** 2h  
Guided activities: 2h  |

**Description:**  
Problems on variable forces will be solved and discussed.

**Support materials:**  
Online version of exercise collection and solved examples.

**Descriptions of the assignments due and their relation to the assessment:**  
Students will hand in proposed exercises.

**Specific objectives:**  
Understand and solve variable forces exercises.

| **OSCILLATIONS** | **Hours:** 2h  
Guided activities: 2h  |

**Description:**  
Exercises on oscillators of different types will be solved and discussed.

**Support materials:**  
Students will hand in proposed exercises.

**Specific objectives:**  
Understand the physics of oscillations of different types. Analyse the dynamics of oscillations. Understand the concept of resonance and its relevance in practical situations.
<table>
<thead>
<tr>
<th>TÍTOL ACTIVITAT</th>
<th>Description</th>
<th>Support materials</th>
<th>Specific objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5: CONTROL DE PROBLEMES I</strong></td>
<td>A test will be done</td>
<td>Hardcopy of test</td>
<td>Let teachers and student grasp the information and understanding achieved by students.</td>
</tr>
<tr>
<td><strong>6: FORCES CONSERVATIVES I CENTRALS. MOMENT ANGULAR</strong></td>
<td>Exercises of this chapter will be solved and discussed.</td>
<td>Online version of exercise collection.</td>
<td>Understand the concepts of conservative and central forces. Understand and use concepts of potential energy and angular momentum.</td>
</tr>
<tr>
<td><strong>7: FORCES QUE DEPENEN DE R AL QUADRAT. ORBITES I LLEIS DE KEPLER</strong></td>
<td>Exercises of this chapter will be solved and discussed.</td>
<td>Online version of exercise collection.</td>
<td>Consolidate understanding of Kepler laws. Understand and apply concepts of orbital motion and orbit transfers.</td>
</tr>
<tr>
<td><strong>8: SISTEMES DE PARTÍCULES</strong></td>
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</tbody>
</table>

**Hours:**
- Theory classes: 2h
- Guided activities: 2h
- Self study: 1h 30m
**Description:**  
Exercises of this chapter will be solved and discussed.

**Support materials:**  
Online version of exercise collection

**Descriptions of the assignments due and their relation to the assessment:**  
Students will hand in proposed exercises.

**Specific objectives:**  
Write Newton Laws for systems of particles. Understand and use the concept of linear momentum. Solve variable-mass problems, specifically the rocket equation.

### (ENG) TÍTOL ACTIVITAT 9: SISTEMA DE COORDENADES MÒBILS

<table>
<thead>
<tr>
<th>Description:</th>
<th>Hours: 4h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiences of this chapter will be solved and discussed.</td>
<td>Guided activities: 4h</td>
</tr>
</tbody>
</table>

**Support materials:**  
Online version of exercise collection.

**Descriptions of the assignments due and their relation to the assessment:**  
Students will hand in proposed exercises.

**Specific objectives:**  
Know transformations of coordinates between different frames of reference. Calculate the velocity and acceleration of a particle in an accelerating frame. Understand and apply the concept of fictitious forces. Solve projectile motion in rotating Earth.

### RIGID SOLID I

<table>
<thead>
<tr>
<th>Description:</th>
<th>Hours: 2h</th>
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</thead>
<tbody>
<tr>
<td>1-dimensional rotation concepts will be reviewed. Moments of inertia will be calculated.</td>
<td>Guided activities: 2h</td>
</tr>
</tbody>
</table>

**Support materials:**  
Online version of exercise collection.

**Specific objectives:**  
Consolidate concepts of 1-dimensional rotation. To be able to calculate moments of inertia.

### RIGID SOLID ROTATION II

<table>
<thead>
<tr>
<th>Description:</th>
<th>Hours: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercises about tensors of inertia and Euler equations will be solved and discussed.</td>
<td>Self study: 2h</td>
</tr>
</tbody>
</table>

**Support materials:**  
Online version of exercise collection.
### Descriptions of the assignments due and their relation to the assessment:
Students will hand in proposed exercises.

### Specific objectives:
Consolidate concepts of rigid solid. Solve exercises involving tensors of inertia and Euler equations.

### Euler Angles and Euler Angle Rates

<table>
<thead>
<tr>
<th>Description:</th>
<th>Exercises on Euler angles and Euler angle rates will be done and discussed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support materials:</td>
<td>Online version of exercise collection</td>
</tr>
</tbody>
</table>

### (ENG) TÍTOL ACTIVITAT 13: CONTROL DE PROBLEMES II

<table>
<thead>
<tr>
<th>Description:</th>
<th>Test on concepts presented along the course.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support materials:</td>
<td>Hardcopy of test questions</td>
</tr>
</tbody>
</table>

### Specific objectives:
Visualise and calculate motion in terms of Euler angle and their variation rates.

### (ENG) TÍTOL ACTIVITAT 16: PROJECTE DE L’ASSIGNATURA

<table>
<thead>
<tr>
<th>Description:</th>
<th>Students will develop a project related to Classical Mechanics in groups of 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support materials:</td>
<td>Online version of project proposed</td>
</tr>
</tbody>
</table>

### Specific objectives:
Probe students' understanding, as well as their capabilities of analysis and application to practical cases.
Qualification system

Criteria defined at the subject's infoweb will be applied.
- Half term exam (31%) and final exam (39%)
- Test (10%)
- Project and associated test (20%)

Regulations for carrying out activities

All the proposed activities are compulsory. Thus, any activity which is not presented will be marked as 0. Exams and controls will be written individually. Oriented activities and projects will be done either individually or in group, according to the instructions given in each case.

Bibliography

Basic:


Complementary:

Goldstein, Herbert; Safko, John; Poole, Charles P. Classical mechanics. 3a ed. San Francisco: Addison-Wesley, 2002. ISBN 0201657023.


Others resources:

General course on physics with Java applets: http://www.sc.ehu.es/sbweb/fisica/