240401 - Advanced Mechanics

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 712 - EM - Department of Mechanical Engineering
Academic year: 2017
Degree: BACHELOR'S DEGREE IN INDUSTRIAL TECHNOLOGY ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 3
Teaching languages: Catalan

Teaching staff
Coordinator: Font Llagunes, Josep Maria

Degree competences to which the subject contributes

Specific:
1. Knowledge on machines and mechanisms theory principles.

Teaching methodology

The objectives of the syllabus require a deep understanding of concepts. Such insight is a prerequisite to confidently tackle the great variety of engineering problems at hands. In order to achieve this understanding, all the lectures include the study and resolution of conceptual questions. Some of the lectures include also direct demonstrations with mechanical devices and computer simulations illustrating the concepts and methods. Problem-solving sessions are organized around open questions and problem statements that depart from routine rehash. The students are required to think about the behavior of mechanical systems, previously presented in a figure, and discover the most interesting aspects to be studied. Once the questions to be answered have been formulated, a road-map is proposed and followed. The validity of the final results is then assessed, and the relevant mechanical parameters in the system are identified.

The Digital Campus is used to provide the figures associated with the questions and exercises discussed in the classroom. Collections of four questions, dealing with the concepts presented throughout the week, are also provided weekly for self-evaluation.

Learning objectives of the subject

General goal
To deepen in the study of Mechanics so that problems encountered in the field of Industrial Engineering and, more particularly, in that of Mechanical Engineering, can be solved with rigor.
Specific goals
To enlarge the training on Mechanics with an introduction to Analytical Mechanics, Percussive Mechanics and Mechanical Vibrations.
To deepen the study of redundancy in constraints, and to illustrate practical aspects of gyroscopy.
## Study load

<table>
<thead>
<tr>
<th>Total learning time: 75h</th>
<th>Hours large group:</th>
<th>0h</th>
<th>0.00%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>30h</td>
<td>40.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>0h</td>
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<td></td>
<td>Guided activities:</td>
<td>0h</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>45h</td>
<td>60.00%</td>
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## Content

<table>
<thead>
<tr>
<th>Topic</th>
<th>Learning time: 14h</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Redundancy in constraints</td>
<td></td>
<td><strong>Description:</strong> Total redundancy and tangent redundancy. Underdetermined and ill conditioned constraint forces.</td>
</tr>
<tr>
<td>Method of virtual work</td>
<td></td>
<td><strong>Description:</strong> D'Alembert inertia forces. Particular case of the rigid body. Virtual motions and works. Determination of equations of motion and constraint forces.</td>
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<tr>
<td>Lagrange equations</td>
<td></td>
<td><strong>Description:</strong> Generalized forces: inertia, conservative, and non conservative. Ordinary Lagrange equations. Lagrange equations with multipliers. Hamilton principle of minimum action.</td>
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<tr>
<td>Introduction to vibrations of N DOF</td>
<td></td>
<td><strong>Description:</strong> Linealization of Lagrange equations: inertia matrix and stiffness matrix. Vibrational eigenfrequencies and eigenmodes of undamped systems. Free vibrations. Orthogonality of the eigenmodes.</td>
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Qualification is based on two proofs of continuous evaluation and the final exam:

- **Proof 1**: TEST of 6 questions (constraints analysis and virtual work method).
- **Proof 2**: PROBLEM (Virtual work Method and Lagrange equations).
- **FINAL EXAM** made of:
  - TEST if 12 questions (1h 30 min): NTef
  - PROBLEM (1h 30 min) : NPef

The final qualification is the maximum between the following grades:

- **Final exam grade**: NEF = 0,5 NTef + 0,5 NPef
- **Continuous evaluation grade**: 0,18 NProva 1 + 0,22 NProva 2 +0,6 NEF

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### Introduction to percussive dynamics

**Learning time:** 17h

- Theory classes: 5h
- Practical classes: 2h
- Self study : 10h

**Description:**

### Gyroscopy

**Learning time:** 2h

- Laboratory classes: 2h

**Description:**
Gyroscope motions. Turn over tendency of cars in a bent. Motorbike driver action on the handlebar. The monocycle INOKAU-II. Gyroscopic stabilization of a two wheels vehicle, the INOKAU-II.
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Bibliography

Basic:


Complementary:


Others resources:

What can be found in the Digital Campus:
- Work material for theory and practical lectures.
- The publication "Ampliació de Mecànica, resolucions de qüestions i problemes. Vol.1" (J. Agulló i Batlle. Publicacions OK Punt) with the explained resolution of 23 Test questions and 2 problems.
- Self-evaluation questions for the weekend.
- A significant sample of past exams, with the complete resolution of exercises and the answer to the multiple-choice tests.
- Information concerning the course organization, the compilation of formulae to be used in exams, the grade lists, the test solutions and problem resolutions of the exams corresponding to the running semester.